How the Brain & Senses Work

Huberman Lab Keypoints

Episodes in this pack: 19

Bringing Extinct Species Back to Life | Dr. Beth Shapiro

Guest: Dr. Beth Shapiro
Date: 2026-10-05 · Duration: 2:15:37
URL: https://www.youtube.com/watch?v=SFX8FIHFLE4

KEYPOINTS

1. 'Species' is a human label, not a biological fact
Shapiro says 'biology doesn't care what species you are.' The biological species concept (Ernst Mayr: can two animals interbreed?), genetic-similarity cutoffs and geographic labels (Florida vs. Texas panther) are all valid tools for different conversations. Her example: Linnaeus named American bison 'buffalo' because Europeans gave that name to any big animal that looked like it would make a good coat.

2. Interbreeding between related lineages is common
Humans and Neanderthals split about 300,000–500,000 years ago. Brown and polar bears split about half a million years ago and still interbreed wherever their ranges overlap, producing 'grolar' or 'pizzly' bears. Ancient DNA from a polar bear that lived off Alaska more than 100,000 years ago already carried brown-bear ancestry.

3. Everyone carries a different 2–5% of Neanderthal DNA
The Neanderthal pieces in one person's genome differ from another's. Pooled across living people, they rebuild more than 90%, possibly over 95%, of the Neanderthal genome. So most Neanderthal DNA wasn't harmful. Most of it sits at about 3% frequency and isn't under selection. The interesting signal is a Neanderthal segment that is suddenly common in a population, which suggests it helped.

4. Neanderthal genomes help pinpoint what makes us human
Comparing humans with chimps means sifting 3–5 million years of change, most of it neutral copying errors; every child has about 100 new mutations compared with its parents. The Neanderthal genome cut the window to 300,000–500,000 years. The roughly 5% of the genome where no living person carries Neanderthal DNA is where the human version was apparently essential.

5. De-extinction means editing a living relative, not Jurassic Park
No DNA survives from dinosaurs, which died out more than 66 million years ago. The oldest DNA ever recovered is from mammoth bone about 1–2 million years old. Colossal sequences extinct genomes, finds the key differences from the closest living relative, and edits those into the relative's cells. Mammoths are closer to Asian elephants than Asian elephants are to African elephants, and the two genomes are already nearly identical.

6. The dire wolves are gray wolves with 20 targeted edits
From fossil dire wolf genomes the team identified variants for bigger size, sturdier build and a light coat, then engineered 20 edits into gray wolf cells. For the light coat they used a route already known to be safe instead of copying the dire wolf variant directly. Romulus and Remus are almost two years old and Khaleesi is about 18 months. They're too closely related to breed, so hormones are used to prevent it.

7. A mammoth is a much harder engineering problem
A woolly coat requires changes not just to hair but to skin: room for more follicles and sebaceous glands. Elephants carry for 22 months and mature at about 14 years, so any edit has to produce a healthy, long-lived animal. Because hundreds of mammoths can't come from hundreds of pregnant Asian elephants, Colossal is developing artificial wombs, for now in mice.

8. Birds can't be cloned, so the dodo drives new tools
Somatic cell nuclear transfer, the Dolly-the-sheep method used for mammals, doesn't work in birds because their egg cells can't be accessed at the right stage. Birds are among the most endangered animals, so the dodo program is meant to develop bird technologies. It was picked partly for wonder: the 'cool beak' and its Alice in Wonderland fame draw public interest.

9. De-extinction and conservation use the same toolkit
Shapiro's answer to 'why not save living species instead?' is that Colossal does both. Excitement about mammoths, dodos and thylacines brings in funding and engagement for technology that also protects living species. Humans have been reshaping ecosystems for tens of thousands of years, by hunting large animals in Australia about 50,000 years ago and in Asia about 30,000 years ago, and then through domestication.

10. Gene drives can be built with limits
Rather than wiping out mosquitoes, Shapiro favors engineering them so they can't carry disease. A gene drive spreads an edit through the wild population, but it can be designed to last only a set number of generations, with appropriate safety measures.

EXAMPLES

1. A one-letter edit to protect the northern quoll
Northern quolls, small carnivorous marsupials, die when they eat invasive cane toads and may go extinct within decades. Some mammals elsewhere tolerate the toad toxin thanks to a single amino-acid change in one gene. Colossal Australia partners made that change in quoll cells, and lab-dish tests suggest it could let quolls survive eating the toads.

2. Florida panther genetic rescue
By the 1990s inbred Florida panthers had crooked tails, cowlicks and undescended testicles. Texas panthers were brought in during the mid-1990s and the defects disappeared for a while. Now that the population is cut off again, inbreeding is returning, so the rescue has to be repeated.

3. Black-footed ferrets and Elizabeth Ann
Thought extinct, the species turned up when Shep, a family dog near Meeteetse, Wyoming, killed one; the taxidermist recognized it. Every ferret alive descends from a small captive group. In 2020 Elizabeth Ann was cloned from tissue frozen about 40 years earlier at the San Diego Frozen Zoo, to restore lost genetic diversity. She couldn't reproduce, but a later clone from the same line has had offspring.

4. Cloned red wolves
Alongside the dire wolves, Colossal announced cloned red wolves, North America's most endangered wolf. Princeton's Bridgett vonHoldt found coyote-like animals with more than 75% red wolf ancestry, which are being used to add genetic diversity to the small captive population in the Carolinas.

5. The American chestnut
A fungus brought in on imported Chinese chestnut trees killed about a billion American chestnuts in the early 20th century. Shapiro cites a gene-edited chestnut, which she calls the first organism engineered for conservation, being deregulated by the USDA.

OTHER RELEVANT

1. Judge projects by staged risk analysis
Shapiro argues every release or relocation should be staged and modeled for risks and rewards. Humans are already the stewards of ecosystems they have changed, and doing nothing is also a choice.

2. Read ancestry results with care
Neanderthal DNA isn't 'vigor genes.' Most segments are neutral, and the 2–5% differs from person to person.

3. Height and trait genes have deep histories
Many height-related variants came into Europe with Steppe (Yamnaya) migrants about 4,700 years ago. Northern European height has plateaued, which suggests a ceiling for the current gene pool.

4. Fear of new biotech tends to fade with familiarity
Shapiro notes the 'big fear wall' around new technologies often comes down once people encounter the results. She sees clear public communication as part of the scientific work.

What Humans, Animals and Plants Tell Us About Consciousness | Michael Pollan

Guest: Michael Pollan
Date: 2026-09-28 · Duration: 2:02:19
URL: https://www.youtube.com/watch?v=nk15CT41MFc

KEYPOINTS

1. Consciousness is easy to recognize but hard to define
Pollan starts from a few working definitions. One is simply subjective experience: a toaster has none, and he argues current AIs don't either. Another comes from philosopher Thomas Nagel's 1970s essay 'What Is It Like to Be a Bat?': if there is something it is like to be a creature, it is conscious. By that standard bats count, even though we can only roughly imagine navigating by sonar.

2. Humans long assumed they had a monopoly on consciousness
From Descartes onward, other animals were assumed not to be conscious. Pollan notes that the first mirror self-recognition test on chimpanzees was only around 1970, about 55 years ago, when scientists began accepting that other primates are conscious too. Building a universal standard around our own version of consciousness, he says, seems 'kind of crazy.'

3. Consciousness may start with feelings in the brainstem, not thoughts in the cortex
Pollan was persuaded by a line of work from Antonio Damasio in the 1990s and, more recently, South African psychiatrist and neuroscientist Mark Solms. Their view is that the brain exists to keep the body alive around homeostatic set points. The body reports on those set points through feelings like hunger, warmth, cold and itch, and consciousness arises from registering and acting on those feelings.

4. Most vagus-nerve traffic runs from body to brain
Pollan says about 80% of the information in the vagus nerve flows from the visceral organs up to the brain. Huberman, who teaches neuroanatomy, confirms the figure and puts the descending share at roughly 15–20%, though nobody knows exactly. They argue that we lack language for most bodily signals. Huberman suggests our current state may reflect body signals integrated over the previous ~10 hours.

5. Plants show problem-solving that looks like intelligence
Pollan distinguishes intelligence from consciousness but argues that plants handle novel problems, not just programmed reflexes. His examples are corn roots solving a maze and plants responding to the sound of feeding caterpillars. He doesn't think plants have the deliberate awareness that social life demands, but calls plant intelligence a fascinating field.

6. Awareness may exist because social life can't be pre-programmed
Most of what the brain does, like monitoring the body and adjusting to the environment, happens without awareness. The most persuasive explanation Pollan has heard, which he admits is an evolutionary 'just-so story,' is that human society is so complex that you can't automate every move. That requires theory of mind, imagination and deliberate choices.

7. Consciousness without a self is possible
Pollan points to the roughly 500 milliseconds after waking when you are reconstituting who and where you are. Huberman jokes it's 750 ms in a hotel room. That suggests consciousness doesn't have to be organized around a self, something Buddhists have long held. Pollan says psychedelics and experiences of awe also reduce the sense of ego, in a pro-social way.

8. Pollan keeps 'filter' theories of consciousness open
After surveying the theories, Pollan concludes we have no real idea how brain matter generates consciousness, if it does. Some argue the brain channels consciousness like a radio or TV receiver: you wouldn't look inside the set for the weather presenter. He doesn't endorse this view, or panpsychism, but no longer dismisses either.

9. Building a conscious AI would test the feelings theory
Some individuals and companies are trying to make AI conscious, not just intelligent, and those are different goals. If consciousness originates in feelings, it may depend on having a vulnerable body and perhaps mortality. Success or failure would both be informative.

10. Caffeine is a drug most of us are dependent on, and mostly a beneficial one
Roughly 90% of adults use caffeine daily, as coffee, tea or yerba mate. Pollan says it has many health benefits up to about seven or eight cups a day, after which problems begin, and some people get jittery on much less. He cites benefits for Parkinson's and blood pressure, plus polyphenols in coffee and tea that help the microbiome. These are his claims from researching the topic.

EXAMPLES

1. Awe shrinks the self, literally on paper
Pollan describes an experiment by Berkeley colleague Dacher Keltner. People drew a stick figure of themselves on graph paper, then had an experience of awe such as river rafting, then drew themselves again. The second figure was about a third the size, which Pollan reads as a healthy, pro-social reduction in ego.

2. Corn roots in a maze
Give a corn plant a maze with ammonium nitrate fertilizer in one corner, and its roots find the fastest path to it. Pollan stresses this isn't a situation the plant meets in nature, so it can't simply be programmed behavior.

3. Xenobots: behavior without genetic instructions
Tufts biologist Michael Levin takes skin cells from tadpoles and puts them in a solution, where they clump into a new

organism that lives about a week or two. These 'xenobots' repurpose their cilia to move, can be conditioned and can navigate mazes, though nothing in their genes encodes those instructions. Levin also argues that memory can be stored in bioelectric fields in groups of cells, not only in neurons.

4. Pollan's three-month caffeine fast

Roland Griffiths, the Johns Hopkins psychopharmacologist who launched the psilocybin research renaissance and earlier studied caffeine, told Pollan you can't understand a habitual drug until you get off it. Pollan had been drinking coffee since age 8–10 at breakfast with his often-absent father. Quitting cold turkey brought flu-like symptoms. Even after they eased, he didn't feel like himself for about three months. His first cup back was 'better than any psychedelic experience': he cleaned his closet and the garden. The second cup was less special.

5. Ibogaine's unusual path to approval

Pollan notes that ibogaine, the psychedelic nobody wants to use recreationally and one never put through university drug trials, looks set for approval first. He credits veterans' advocacy and says the push followed Joe Rogan texting the president. The same executive order is fast-tracking MDMA for trauma (Resilient, formerly Lykos, previously turned down and now resubmitted) and Compass Pathways' psilocybin. Pollan questions whether this is how drugs should be approved.

6. Two food chains

In a roughly 8,000-word New York Times piece that became a chapter of The Omnivore's Dilemma, Pollan followed one cow from insemination to slaughter. He contrasted an oil-based corn feedlot system, in which the corn makes animals sick and requires drugs, with a sunlight-and-grass chain. He insisted on including the hopeful alternative, grass-fed beef, which was then a tiny market, and later visited Joel Salatin's rotational grazing farm in Virginia.

OTHER RELEVANT

1. Try a caffeine break to learn your relationship with it

Following Griffiths' advice, a period fully off caffeine shows how dependent you are. Expect withdrawal symptoms for a few days and possibly feeling 'not yourself' for longer. Pollan frames drugs as neither good nor bad but dependent on context.

2. Seek awe deliberately

Awe can come from nature, rafting, music or psychedelics. Pollan presents its ego-shrinking effect as good for relationships and perspective, not just pleasant.

3. Treat the garden as a laboratory

Pollan argues that about 8% of US land is protected and the rest is either 'virgin' or exploited. Learning to work with nature where we live, as in a garden, teaches more than visiting wilderness.

Using AI to Increase Your Intelligence & Enrich Humanity | Dr. Fei-Fei Li

Guest: Dr. Fei-Fei Li
Date: 2026-08-10 · Duration: 2:08:13
URL: https://www.youtube.com/watch?v=N5AQFYtqx8Q

KEYPOINTS

1. Vision is a cornerstone of intelligence, in both evolution and AI.
Li notes that animals first 'saw light' about 540 million years ago (trilobites and their relatives). Within roughly 10 million years came the Cambrian explosion, as sensing drove active hunting, mate-seeking and rapid speciation. Today an estimated half of human cortical activity is involved in vision, and children are visual before they are verbal. Computer vision likewise sparked the modern AI moment.

2. Modern AI came from three things converging around 2012: neural networks, big data and GPUs.
Simple neuron-like algorithms date to the 1950s: units that take an input, apply a simple function and pass an output on, stacked into networks. By around 2010 the algorithms had matured, GPUs made massively parallel computing possible, and the internet supplied data. Li's key insight was that big data had to drive these algorithms, which led to ImageNet.

3. The same recipe, a better algorithm plus more data plus more compute, produced ChatGPT.
The transformer paper (around 2016–2017) proved more powerful than the earlier AlexNet-style networks, and this time natural language processing made the leap, using the internet's text. It still took about five years, from 2017 to 2022, to reach the 'ChatGPT moment.' From about 2023, teams added video to training data, leading to text-to-video tools like Sora.

4. AI is bounded by what humans have captured; uncaptured, personal thought stays uniquely human.
Li argues that a deeply personal thought or feeling (the emotion behind a piece of abstract art, say) was never recorded, so it isn't on the internet and AI hasn't seen it. Neuroscience can't even say which brain area such a thought comes from. AI deserves credit for combining information creatively, but that combining is a different thing from human experience.

5. AI 'creativity' is real but special, and it thrives where the rules are clear.
AlphaGo's famous Move 37 is often cited as machine creativity, but Li stresses that Go has clear mathematical objectives and rules. Greater compute and memory let AI explore moves human brains don't typically consider. She calls that creativity, but 'a special kind.'

6. Context in a prompt is not intuition, but it changes the answer.
Asked whether AI could ever have intuition about something like a sibling relationship, Li separates intuition from creativity. Telling a chatbot 'I'm a Stanford professor and neuroscientist' versus 'I'm a 14-year-old who loves race cars' gives it context, which already reshapes the response. She tries to describe a scientific process for how any such capability could arise rather than treating it as mystical.

7. AI should augment human agency, never take it away.
Li says agency, motivation and dignity matter at every individual level, and AI leaders should not talk as if the technology will strip people of them. She criticizes experts who talk down to the public and decide for them. People deserve education on the pros and cons, and the choice. She left Google to co-found Stanford's Human-Centered AI Institute in 2018, before ChatGPT, because she saw these societal questions coming.

8. For kids, the worst outcome is AI killing the motivation to learn, and banning it is also bad.
Li's pessimistic scenario: doom-scrolling and passive shorts erode agency, when real learning 'takes time, takes effort, sometimes takes some pain' for a brain that must go through developmental phases. The opposite danger is denying students the tools out of fear of cheating. With motivation intact, AI can take learning deeper, and she predicts such a generation would be 'way smarter than us.'

9. Technology limits are social choices, not just technical ones.
Li's example: any carmaker could program brakes to fail every Friday, a trivial piece of technology, but laws, norms and morality stop it. AI likewise has to move from purely technical discussion into social and legal discussion, even amid pressure from the 'AI race' to go faster.

10. The next frontier is spatial and physical intelligence beyond language.
Humans develop preverbally first, and evolution ran about 500 million years without language. Li's company, World Labs, builds foundation models that generate 3D and 4D worlds for creators, robot training, architecture, healthcare and education. She sees robotics, or 'embodied AI', as the step after language models.

EXAMPLES

1. ImageNet and its challenge
Li's lab assembled ImageNet, about 15 million images of everyday objects and the first internet-scale AI dataset. From 2010 it ran a public challenge: name the main object in an image across 1,000 categories, using a test set of more than a million images. A Stanford graduate student benchmarked human error at a few percent. In 2012 neural networks, ImageNet and GPUs together cut machine error into the teens, the turning point of modern AI.

2. Learning 'cat' from a glimpse of a tail
Huberman uses a child learning 'kitty cat' to frame object constancy, recognizing a cat from the side, the back or just its tail. Li explains that generations of computer scientists tried to hand-code this before data-driven learning finally made it reliable.

3. Eddie Chang's speech neuroprosthetics
Huberman describes neurosurgery chair Dr. Eddie Chang (his childhood friend) decoding neural activity for the larynx and pharynx so paralyzed, locked-in patients can speak, one for the first time in 10 years. One woman, who uses a wheelchair,

speaks through an iPad avatar built from her wedding video, voice and movement patterns. Li calls this embodiment.

4. The action potential paper nobody wanted to deal with

Huberman recalls a Nature paper from about 12 years earlier showing that action potential shapes vary within a neuron, which contradicts textbooks. Scientists largely ignored it because it broke the rules. His point is that AI given the right rules could handle such complexity better than experts trained on fixed rules.

5. Exhausted nurses and isolated elders

After a month in hospital with her father, Li describes nurses walking miles per shift to fetch supplies and medicine, and elderly people living alone who struggle to get groceries or go for a walk. These are the jobs she sees robots helping with, amid a caretaker shortage.

OTHER RELEVANT

1. Learn to prompt the Socratic way

Li calls prompting a real skill she'd like taught in K–12 schools. Her answer to 'who is humanity's best prompter?' is Socrates, because his method sought truth by asking questions. She also says AI has stopped her from asking 'lazy questions' of colleagues.

2. Use AI as a tutor when you're stuck

Recalling how hard organic chemistry was in premed, with too few TA and office hours, Li says an AI companion would have let her ask endless questions about exactly where she was stuck. The motivation has to come from you; the tool supplies guidance.

3. Consumer versus creator mode

Huberman approaches AI as a consumer when he knows nothing about a topic and as a creator when he already has knowledge to build on. Both note that brain plasticity continues throughout life, so adults can learn these tools too.

4. Don't forget teachers and parents

Li is optimistic about curious kids. She worries about teachers and some parents, whom Silicon Valley and policymakers rarely consult, and she makes a point of talking with them wherever she goes.

How to Expand Your Consciousness | Dr. Christof Koch

Guest: Dr. Christof Koch
Date: 2025-09-15 · Duration: 2:11:42
URL: https://www.youtube.com/watch?v=2t4vswC-3mY

KEYPOINTS

1. Consciousness is simply experience
Koch, of the Allen Institute and the Tiny Blue Dot Foundation, defines consciousness as the fact that you see, hear, love, dread and dream, not your ability to respond. In early-night deep non-REM sleep or under anesthesia, 'you do not exist for yourself'. Dreams, by contrast, are conscious experiences.

2. Self-consciousness is only one part of consciousness
People confuse consciousness with having a sense of self. In flow, as when Alex Honnold climbs, in meditation or on psychedelics, the inner critic can go quiet while awareness stays high. Koch calls this 'blessed silence'.

3. Consciousness is about being, not doing
You can be highly conscious while motionless, in meditation, dreams or mystical states, and much behavior is unconscious. Koch argues this is why intelligence and consciousness are separate: computers may match everything we do without being anything.

4. Koch says the circuits linking cortex and thalamus generate experience
A beating heart and an active brainstem are enabling conditions, since without blood flow you lose consciousness within about 8–10 seconds. But Koch says the content of experience comes from the circuits linking the cortex and thalamus, and work at the Allen Institute manipulating these circuits supports this.

5. A 'zap and listen' test can measure consciousness
Researchers stimulate the brain with transcranial magnetic stimulation and record the echo with high-density EEG to compute a perturbational complexity index (PCI) from 0 to 1. Waking, dreaming and ketamine dissociation score high, while deep sleep, anesthesia and brain death score low. Across about 300 people, a sharp threshold of about 0.31 separated conscious from unconscious.

6. About a quarter of 'unresponsive' patients are covertly conscious
A large New England Journal of Medicine study found that about 25% of behaviorally unresponsive patients could voluntarily modulate motor-cortex activity on command ('clench your fist for 30 seconds'). Families often decide to withdraw care within days, so Koch founded a company, Intrinsic Powers, to bring testing into the ICU. The FDA has asked for a clinical trial, and his pilot data suggest covertly conscious patients recover more often.

7. We live inside a personal 'perception box'
Borrowing the term from Elizabeth Koch, he describes everyone's reality as built from Bayesian priors: expectations about the world, other people and oneself. #TheDress (white-gold versus blue-black, possibly linked to whether people are morning or evening types) is the harmless version. Opposing readings of 9/11 or October 7 show the same process in politics.

8. Transformative experiences change your priors fast
Reading and films shift you slowly. Direct, first-person 'acquaintance' with something can rewrite your priors in minutes, and the deliberate reworking afterwards is what psychedelic therapy calls integration.

9. You have to believe you can change
Koch believes the mind stays changeable at almost any age. If you're told your condition is hopeless and to 'take this pill and suffer', you won't improve, so seeing yourself as an active agent of your own mind is a precondition for therapy. He credits Alcoholics Anonymous's admission that you can't do it alone, and the community it provides, rather than divine intervention.

10. Belief drives treatment effects
Koch cites a study by Stanford's Boris Heifets: depressed patients having surgery got either ketamine or none under full anesthesia. Both groups improved similarly, and recovery tracked how strongly patients believed they'd received ketamine, which is why Koch says cynicism undermines therapy.

EXAMPLES

1. Oliver Sacks imagining being a bat
Koch, a friend of the neurologist through Francis Crick, says Sacks' gift was empathy: imagining patients' strange inner worlds, such as a man whose memory stopped 20 years earlier. Koch believes we can approximate what it's like to be a bat, contrary to Thomas Nagel's famous essay. To him, that attempt is what empathy is.

2. Koch's 5-MeO-DMT experience
Within three inhaled breaths his visual field fractured into hexagons and his sense of self vanished. All that was left was a point of bright light, terror and ecstasy, with no space or time, and he recovered within an hour with little change in heart rate. He says it taught him that mind doesn't need space, time or a self, and that his fear of death disappeared within weeks. He says he'll never do it again.

3. A VR lesson in being someone else
In Jeremy Bailenson's lab at Stanford, Huberman's avatar became a Black man facing subtle slights on the street and in a job interview. In about 10 minutes, the 2017 experience left him lastingly aware of how others glance at him, which Koch calls a transformative experience.

4. The 'Jennifer Aniston neuron'

Recording from epilepsy patients with neurosurgeon Itzhak Fried at UCLA, Koch's lab (Rodrigo Quian Quiroga and Gabriel Kreiman) found hippocampal-region cells that fired to different pictures of one person, such as Jennifer Aniston or Bill Clinton, and sometimes to their written name.

5. Locked-in patients and the will to live

An Israeli study found that most locked-in patients, except those in chronic pain, wanted to keep living, even though most people beforehand would say they wouldn't. Koch calls this disability bias and notes it complicates advance directives.

OTHER RELEVANT

1. Try Huberman's 'spacetime bridging' meditation

Spend about three breaths on each step: eyes closed, sensing from the skin inward; then eyes open on your own body; on a point 8–10 feet away; on the farthest point you can see; then imagine Earth as a rock spinning in space; then return to your body. Huberman designed it to move between perspectives.

2. Build body awareness in young people

Koch links declining adolescent mental health, which he says began before social media and worsened during the pandemic, to poor interoception, the loss of unsupervised play, filtered social comparison and smaller families. He supports therapies that teach kids to read their body states.

3. Koch's reading and outlook

Koch recommends Marcus Aurelius on controlling how you respond to events. His advice for life: never stop trying to understand the world, and leave it better than you found it.

Curing Autism, Epilepsy & Schizophrenia with Stem Cells | Dr. Sergiu Pa!–6

Guest: Dr. Sergiu Pa!–6
Date: 2025-08-18 · Duration: 2:23:15
URL: https://www.youtube.com/watch?v=H4mMZ0vliMo

KEYPOINTS

1. Autism is a behaviorally defined spectrum, not one disease
Pa!–6 æ÷FW2 F† B WF—6Ò † 2 æò &–öÖ ker and is diagnosed by the presence or absence of behaviors by a certain age. Prevalence is now close to 3%, whereas it was considered rare when he was in medical school. He compares today's 'autism' to 19th-century 'fever,' which could be an infection, cancer or an autoimmune disease needing very different treatments. His lab focuses on profound autism, the severe forms that often come with intellectual disability or epilepsy and may require lifelong care.

2. Genetics are strong; the 'refrigerator mother' idea was wrong
Psychoanalysts in the 1950s–60s blamed emotionally cold mothers. Twin studies in the 1970s showed that if one identical twin has autism, the other very likely does too, and heritability is among the highest of psychiatric conditions. Only in the last 10–15 years have specific genes been tied to profound forms. Prevalence in Scandinavia is around 1 in 30 to 1 in 40, similar to the US, which Pa!–6 6 ys weakens US-specific explanations like glyphosate.

3. The male bias is about 4:1 and may reflect developmental resilience
The ratio varies with severity but is generally around 1 female to 4 males. Pa!–6 ö–çG2 ÷WB F† B &V–ær `emale is one of the best predictors of good outcomes in premature babies, and that male and female nervous systems mature at different paces and may handle injury differently. With autism being many conditions, he cautions against pinning the bias on any one factor.

4. Vaccines and the 'fever effect'
Huberman states for the record that he sees no solid evidence that vaccines cause autism, and Pa!–6 prees there is none epidemiologically. Parent reports that non-verbal children briefly speak in sentences during high fevers are 'mostly anecdotal.' Proposed explanations include noradrenergic activation, cytokines reaching the brain and temperature-sensitive ion channels.

5. Gene therapy options and their limits for the brain
Approaches include adding a missing gene via engineered, non-disease-causing adeno-associated viruses, delivering a missing enzyme directly, or editing DNA with CRISPR (already used for sickle cell disease in blood). The brain is hard to reach: delivery is by surgery or intrathecal injection, viral payloads and efficiency are limited, large genes such as calcium channels don't fit in a virus, and immune responses often allow only one shot. Pa!–6 w2 Æ " –ç7FV B F &vWG2 F†R $ä 7FW downstream.

6. Yamanaka factors turn skin cells into stem cells that can become brain tissue
About 20 years ago, Shinya Yamanaka showed that four factors can revert a specialized cell, such as a skin fibroblast, into an induced pluripotent stem (iPS) cell. This sidestepped embryonic-cell ethics, and Pa!–6 Æ–°ens it to alchemy. Without signals pushing them elsewhere, these cells become neural cells 'almost by default' within days. That lets researchers grow neurons from any patient, including those with rare mutations.

7. Organoids keep an intrinsic developmental clock
Floating 3D balls of cells, inspired by Yoshiki Sasai's work, survived far longer than expected, and the lab kept cultures for 500–800+ days. Without hormone changes or any change in the culture medium, NMDA-receptor subunits (2B down, 2A up) switched to a postnatal signature around nine months, matching birth. Pa!–6 pants to learn whether this timer could be sped up to model aged neurons, for example for Parkinson's, or reversed to rejuvenate them, but says they only have clues so far.

8. Assembloids rebuild circuits by combining parts in the right order
Combining a cortical organoid, a spinal cord organoid and a ball of human muscle yields a circuit in which stimulating the cortex makes the muscle contract within weeks. A four-part sensory assembloid (pain-sensing neurons, spinal cord, thalamus, cortex) only self-assembles in that order. After hundreds of days, the whole pathway flickers in sync. It's being used to study sodium-channel mutations that cause either excessive pain or a dangerous inability to feel pain.

9. Transplanted human organoids integrate into rat brains
Cortical organoids placed into the somatosensory cortex of newborn rats became vascularized, were colonized by rat microglia, and grew to occupy about a third of one hemisphere. They responded when the rat's whiskers on the opposite side were moved. Human neurons grew six to eight times larger than in a dish, making disease features visible: Timothy syndrome neurons are about half normal size. Integration works because the young rat brain is still 'eager to connect.'

EXAMPLES

1. Timothy syndrome: from a single letter to a clinical trial
A one-letter mutation in a calcium channel causes webbed fingers, autism and epilepsy. Patient-derived neurons showed calcium lingering in the cells longer than normal. After about 15 years of study in 2D neurons, organoids and assembloids, the lab found a small antisense nucleic acid that changes how the channel is processed and reversed every defect they had described. Pa!–6 † 2 v F†W&VB porldwide patient cohort and begun producing the drug. He calls it the first psychiatric therapeutic developed exclusively in human stem-cell models.

2. Stem-cell clinic harms
Huberman recounts a Florida clinic whose eye injections for macular degeneration left patients blind quickly, after which the FDA shut down commercial stem-cell injections. He also describes a patient paralyzed and nearly killed by an infected spinal-disc injection abroad. Pa!–6 6 ys parents are sometimes urged to take autistic children to clinics in South America or parts of Europe, and he always tells them no because there is no rationale or regulatory oversight.

3. Follistatin gene therapy tourism

Huberman notes that some people in the biohacking community travel abroad for follistatin gene therapy to build muscle. He says he wouldn't do it himself.

4. 22q11.2 deletion and penetrance

This is the most common microdeletion in humans, at about 1 in 3,000 births, and removes around 60 genes. It brings cardiac and immune issues, plus roughly a 30% risk of schizophrenia (about 30 times the 1% population rate) and a 30% risk of autism. Yet some carriers show minimal effects. Pa!–6 GG ibutes the variability to genetic background and possibly environment. By contrast, every known Timothy syndrome patient is severely affected.

OTHER RELEVANT

1. Be skeptical of unregulated stem-cell injections

Ask what cells are being injected, from whom, and on what evidence. PRP is FDA-approved but contains few if any stem cells. Banked umbilical cells have narrow proven uses, such as certain blood disorders, rather than the universal benefits sometimes advertised.

2. Genetic testing can inform but not fully predict

Deletions like 22q11.2 can be tested for, but variable penetrance means a positive result is a risk estimate, not a forecast. Discuss results with a genetic counselor.

3. Expect progress to come first for clear single-gene forms

Pa!–6 6VW2 6öæF—F–öç2 v—F, öæR 6ÆV " vVæWF–2 6 W6P, like Timothy syndrome, as 'Rosetta stones.' He expects therapies or ev
cures for some of them within the next decade, well before treatments for idiopathic autism.

What Pets Actually Want & Need | Dr. Karolina Westlund

Guest: Dr. Karolina Westlund
Date: 2025-04-28 · Duration: 2:05:23
URL: https://www.youtube.com/watch?v=6ck9fa6_C8c

KEYPOINTS

1. Dog breeds are slices of the wolf's predatory sequence
Westlund, an ethologist, describes the wolf hunting sequence: orient and sniff, eye and stalk, chase, grab-bite, kill-bite, dissect, eat. Over the last couple of hundred years, breeding selected different parts of it — hounds for sniffing, pointers for eyeing, others for chasing. Knowing which parts your dog was bred for tells you which behaviors it needs to express.

2. Use the 'core affect space' to judge an animal's emotional state
Plot valence (pleasant to unpleasant) against arousal. The goal is the calm, pleasant quadrant where animals feel safe and socialize. Reduce high-arousal negative states like fear and aggression, and lift animals out of low-arousal negative states (boredom, depression) with stimulating environments. Seeking, foraging, exploration, play and sex sit in the high-arousal pleasant quadrant.

3. Primate-style hugging often reads as restraint
Humans are huggers, but to many animals an embrace or a pat on top of the head is restraint and can feel like a predator's grab. Most dogs prefer the neck or upper chest. Huberman described an experiment suggesting dogs are averse to rapid petting, and slow, deliberate strokes visibly relax them. Westlund links calm handling to co-regulation, a concept from polyvagal theory.

4. 'Dominance' is usually a misused label
To an ethologist, dominance means priority of access to resources, not a dog trying to 'control' you by jumping up. Dogs stay at heel because pulling ahead was followed by something unpleasant, not because of rank. Strip the label away and most behavior has simpler explanations. Much dog training is really owner training.

5. Tail wags and head turns may encode emotion by side
Tail wagging occurs in many contexts and may spread scent from glands as well as signal visually. Wags biased to the dog's left tend to go with negative states and right-biased wags with positive ones. Cats similarly view stimuli more with the left eye in negative states and the right eye in positive ones. Dogs' facial muscles differ from ours, so whole-body language is a more reliable read than the face.

6. Tell play from fighting with 'MARS'
Meta-signals (such as the play bow), Activity shifts (chasing, pouncing, wrestling in jumbled order), Role reversals (taking turns winning, since play stops being fun if you always lose) and Self-handicapping. For example, a big dog in tug-of-war may just hold the toy against a small dog, then engage its full strength when a human pulls.

7. Cats don't bring 'gifts'
Cats carry prey to a place where they feel safe. Many perform only the grab-bite, not the kill-bite, and lose interest once the prey stops moving; movement restarts the sequence. How a cat responds to perceived threat, including from a well-meaning human, depends heavily on early social learning.

8. Wild behavior explains house problems
Covering waste likely reduces infection risk, and animals avoid eliminating where they eat, so keep the litter box well away from food. To diagnose indoor urination, mark every spot on a floor plan: edges near windows and doors suggest territorial marking, while a box linked to pain (for example, painful urination) suggests an elimination problem.

9. Neutering affects behavior as well as reproduction
More than 20 studies over the last two decades, Westlund says, suggest neutering (particularly of males, depending on age) can increase fear, reactivity, aggression and noise sensitivity, and raise the risk of certain cancers and physical problems. Rules vary: Norway bans neutering without a medical reason, while Western Australia requires it unless you're breeding. Alternatives include vasectomy or tubal ligation, which preserve hormones, and reversible chemical castration.

EXAMPLES

1. Huberman's bulldog Costello
Neutered at about six months, Costello had joint pain and fast nail growth by about age nine. Huberman began injecting 50 mg of testosterone a week, and Costello's vigor and mobility returned for roughly two more good years. Instead of criticism, Huberman received hundreds of emails from vets, many of whom discourage routine neutering unless a dog can roam and mate. He is not a vet, and says he wouldn't neuter a future male dog.

2. Cucumber versus grape
In a well-known fairness experiment, a monkey happily accepted cucumber until it saw a neighbor get a grape for the same task, then threw the cucumber back. Westlund and Huberman discussed fairness and altruism in animals while warning against reading benevolence into them.

3. Imprinting gone wrong
In some waterfowl, males learn by sexual imprinting what a female should look like, so if raised by the wrong species they court the wrong females. Westlund recalls a bottle-raised orphan duiker at an African chimp orphanage in 1995 that imprinted on humans and tried to mount her.

4. The San Francisco Zoo tiger attack
Huberman recounted Tatiana escaping her moated enclosure after visitors reportedly provoked her. She ignored the crowd

and targeted specific individuals, prompting an industry rethink of enclosures. Westlund contrasted older menageries with today's in-situ and ex-situ conservation.

OTHER RELEVANT

1. Run a consent test before petting

Scratch a spot the animal likes for a few seconds, then stop. If it leans back in or re-initiates contact, continue. If it moves away, respect the 'no thanks'. Use slow strokes.

2. Feed the predatory sequence safely

Nose work (searching for a target scent, marking it, being rewarded) is a young sport, about 15 years old, with promising early data. It seems to calm anxious, high-strung dogs and energize flat ones. Wildlife chasers can be rewarded for staying in the sniff, point and eye stages; sighthounds like greyhounds can be given safe chances to run.

3. Introduce a new cat gradually, sense by sense

Keep the cats in separate rooms and swap towels rubbed on each to exchange scent. Then let them hear each other, then see each other, and only then allow physical contact. Most species, unlike dogs, don't easily tolerate strangers.

4. Pick a dog that fits your life

Choose a breed whose predatory-sequence strengths and needs match your environment. Constant encounters with strangers in a city raise arousal in many animals.

Charting the Architecture of the Universe & Human Life | Dr. Brian Keating

Guest: Dr. Brian Keating
Date: 2025-01-20 · Duration: 3:07:37
URL: https://www.youtube.com/watch?v=3-ukCGQJk2c

KEYPOINTS

1. Astronomy is the most visceral science
Keating, a cosmologist at UC San Diego, notes that 'cosmos' comes from the Greek for beauty or appearance. We're born with two refracting telescopes in our skulls, the eyes, and Huberman adds that the retinas are brain tissue pushed out of the cranial vault during the first trimester. Cosmology appeals to our pull toward beginnings: the origin of the universe is the one event nothing could witness.

2. Astrology fails the test of being falsifiable
Your sign is set by the constellation behind the sun on your birthday, but the zodiac, dating back 5,000–6,000 years to the Babylonians, ignores Ophiuchus, which the sun passes through for about 17 days in late November and early December. Keating once told an astrologer he was a September-born Gemini and got the same reading anyway. In Karl Popper's terms astrology is unfalsifiable: it can accommodate any outcome.

3. The sky was humanity's first clock
Huberman explains that most animals track day length through melatonin from the pineal gland. Some birds and reptiles have thin skulls or pits that let light reach it directly, but in humans the gland sits deep in the brain and gets light information only through the eyes, so 'ear lights' won't reach it. Knowing whether days were lengthening mattered for a baby's survival, which Huberman suggests is one reason people charted the stars.

4. Our edge is modeling the future, which also makes us find false patterns
Keating notes that 'sapiens' means wisdom, not knowledge. Our strength is the prefrontal cortex's ability to run thought experiments and simulate outcomes. That same habit makes us confuse correlation with causation and fall for confirmation bias, which scientists must guard against most of all.

5. Galileo is Keating's scientific hero
Telescopes grew out of Dutch eyeglass-making, but their inventor only used them as spyglasses. In 1609 Galileo turned one, magnifying about 3–10 times, to the sky. He found mountains on the 'perfect' moon, saw Jupiter's moons, proposed the relativity of motion, invented the tripod, and paired an instrument with a testable hypothesis. Keating adds that Galileo wrongly argued the tides proved Earth moves.

6. Refraction is light slowing in a medium
Light travels about 300,000 km per second in a vacuum and slows in glass or water. Like a row of marching soldiers hitting water at an angle, the beam bends. That's why a coin in a fountain isn't where it looks, and why shaped lenses magnify.

7. BICEP was Keating's lost Nobel
With a $1 million gift from Caltech president David Baltimore's fund (about $10 million in total), Keating designed a microwave-transparent refracting telescope at the South Pole to look for gravitational-wave patterns in the cosmic microwave background, evidence of inflation, the theory of Alan Guth and Andrei Linde. The team announced a discovery at Harvard on St. Patrick's Day 2014 before peer review, for fear of being scooped by a billion-dollar satellite, and it was disproven within months. His book Losing the Nobel Prize tells the story.

8. The South Pole is the best place on Earth to measure faint heat
The target is a few billionths of a degree, so the 5,700-kelvin sun must be below the horizon, which it is for six months at a time. At 9,000 feet it's too cold for much humidity: all the water above it would condense to about a third of a millimeter, compared with roughly 25 mm over Los Angeles. That matters because water absorbs microwaves. Space-based telescopes cost about 1,000 to a million times more.

9. The moon illusion
The moon is always about half a degree wide, the same as the sun, which is why total solar eclipses are possible. It looks huge at the horizon only because buildings and trees give your brain something to compare it to. A pinky at arm's length (about half a degree) covers it either way, and a thumb covers about one degree. Keating adds that the moon drifts roughly a centimeter farther away each year, so total eclipses will eventually end.

EXAMPLES

1. A 12-year-old's first observation
In 1984 Keating mistook a bright 'star' beside the setting moon for a piece broken off it, waited for the Sunday New York Times sky chart, and learned it was Jupiter. A $75 telescope, bought with deli wages and help from his mother, followed.

2. A Nobel chase fueled by an absent father
Keating's father, a mathematician who was a full professor at Cornell at 26, left when Keating was seven. Keating set out to win the Nobel his father never did, but realized the motivation no longer served him after they reconciled. 'Baggage has handles', as his brother says.

3. Scott versus Amundsen
Robert Falcon Scott reached the South Pole about three weeks after Roald Amundsen, found the Norwegian flag, and died on the return journey, weighed down by scientific samples. Amundsen's team used sled dogs for propulsion and, later, food.

4. Visual acuity in numbers
Huberman explains that 20/20 vision resolves about 60 cycles per degree and raptors about 120. That's why a hawk on a

lamppost can see grass rustle below.

OTHER RELEVANT

1. Get out and see a dark sky

Go 20–40 or more miles from a city, or to a dark-sky community such as Julian or Borrego Springs, California, where upward-shining lights are banned. Use your naked eye for meteor showers, such as the Yosemite high country in August. On fall nights you can see the Andromeda galaxy, six times wider than the full moon, which Edwin Hubble showed in 1923 lies far outside the Milky Way.

2. A cheap telescope shows most of the highlights

About $50 will show lunar craters and mountains, Saturn's rings and Jupiter's moons. Keating says you'll see about 90% of what fascinates a beginner.

3. Keating is skeptical about life on other planets

He says there's zero evidence of life beyond Earth. Rock has been exchanged between planets: Mars meteorites such as ALH84001 (Allan Hills), whose announced signs of microbial life were never confirmed, have landed on Earth, and Earth rock carrying life has surely reached Mars. He argues Mars's apparent lifelessness is therefore a meaningful data point, while acknowledging he's an outlier on this question.

How Placebo Effects Work to Change Our Biology & Psychology

Date: 2024-03-04 · Duration: 1:18:16
URL: https://www.youtube.com/watch?v=gdUNjPijwA8

KEYPOINTS

1. Placebo, nocebo and belief effects are distinct but share one engine: expectation
A placebo is an inert pill or behavioral treatment that improves symptoms or performance; a nocebo is an inert treatment that makes them worse. Belief effects occur when specific information you learn changes what you expect, and that expectation produces the outcome. Huberman stresses that none of these are 'just in your head': they change heart rate, blood pressure, hormone output and neuromodulators like dopamine and adrenaline.

2. The prefrontal cortex is the hub that turns expectation into physiology
The prefrontal cortex evaluates context, memories and goals, and largely works by activating or suppressing deeper circuits. Some of its subregions have dedicated 'labeled line' connections to the hypothalamus and brainstem, which control ancient functions such as stress responses, body temperature and breathing. That anatomy is why what you are told about a pill can reach systems you cannot consciously command.

3. A sugar pill can cause measurable dopamine release in Parkinson's patients
In placebo-controlled Parkinson's trials, people told an inert pill would raise dopamine showed symptom improvements and PET imaging evidence of more dopamine release, seen as reduced binding of the tracer raclopride at dopamine receptors. Two caveats keep this from replacing real drugs: placebo-driven dopamine increases are generally smaller than those from L-DOPA, apomorphine or bromocriptine, and the effect shrinks when people realize they are taking a placebo.

4. Placebo responses can be conditioned, not just suggested
Pairing a context with a real physiological effect teaches the body to reproduce that effect. Smells from a bakery or pizza shop raise insulin because of past eating experiences, and in experiments a bell or buzzer paired with food later triggered an insulin rise on its own. Huberman frames this as the brain lumping environmental cues together and making simplified predictions below awareness.

5. Packaging, color and invasiveness change the size of a placebo effect
Brand-name placebos (even invented names with a trademark symbol) outperform generic ones, and pills pushed out of foil or taken from labeled bottles beat pills set on a tray. Capsules beat tablets, injections beat capsules, and inert medical machines that hum and click produce the largest effects. The brain has learned to equate complexity and invasiveness with bigger outcomes.

6. Placebo effects are powerful but specific and limited
In cancer care, placebos can reduce pain, nausea and other side effects of chemotherapy or radiation, improving well-being, but they do not shrink or eliminate tumors. Huberman separates three categories: proven behavioral supports such as sleep, stress reduction and social support, which act by lowering inflammation and stress hormones; real treatments such as drugs, radiation and immunotherapy; and genuine expectation effects, which have limits.

7. Expectation scales with the dose you think you received
In the study 'Nicotine-related beliefs induce dose-dependent responses in the human brain,' everyone vaped the same real dose of nicotine but was told it was low, medium or high. Cognitive task performance and activity in a nicotine-responsive brain region both rose stepwise with the believed dose. Huberman calls it one of his favorite papers because it ties belief, brain activity and performance together.

8. There is a mapped circuit from thought to the stress response
A rat study titled 'A central master driver of psychosocial stress responses' traced a prefrontal region (the dorsal peduncular cortex and dorsal tenia tecta) to the dorsomedial hypothalamus, then to the rostral medullary raphe in the brainstem, and out to the body. This pathway drives blood pressure, peripheral vasoconstriction, body temperature and brown-fat thermogenesis during social stress. Huberman notes analogous circuitry exists in humans. By contrast, no known pathway lets belief grow one quadriceps more than the other.

9. People differ in how strongly they respond to placebos, partly through genes
The first formal placebo study found roughly 30% of participants showed a robust effect and 70% a weaker one, and that spread has recurred across studies. Variation in the COMT gene, which encodes catechol-O-methyltransferase, an enzyme that regulates dopamine, epinephrine and norepinephrine, correlates with the strength of some placebo responses. That fits the fact that many placebo effects involve catecholamine systems.

EXAMPLES

1. Saline injections that mimicked sumatriptan's hormone effects
Subjects learned about growth hormone and cortisol, which alone changed nothing. On days two and three they were injected with sumatriptan, which raised growth hormone and lowered cortisol. On a later day a saline injection produced the same pattern, even when subjects were told it would lower growth hormone. The brain had paired 'injection' with the hormonal outcome.

2. Pill color steers the direction of the effect
Across three separate experiments with identical placebo pills, blue pills produced the best sleep when the pills were described as sleep aids, red pills the biggest boost when described as stimulants, and yellow pills the greatest relief when described as antidepressants.

3. Kaptchuk lab asthma study in the New England Journal of Medicine

Ted Kaptchuk's group at Harvard briefly took asthma patients off medication and gave them no treatment, a placebo, or an active drug. The active drug improved both breathing and discomfort. The placebo reduced reported discomfort, but measured breathing did not change, which shows how specific placebo effects are.

4. Alia Crum's 'Mind Over Milkshakes'

People drank the same 380-calorie shake labeled either as a 620-calorie 'indulgent' shake or a 140-calorie 'sensible' one. Ghrelin, a hunger hormone secreted by the stomach, was measured at baseline, in anticipation and 90 minutes after drinking. It fell more steeply and quickly after the 'indulgent' label, and people felt fuller.

5. Hotel room attendants told their work was exercise

Crum's adviser suggested the benefits of exercise might be placebo. She split hotel housekeepers into a group told their job was important and a group told their daily vacuuming, stair-climbing and cart-pushing counted as exercise that lowers blood pressure and body weight. Only the second group showed improvements in blood pressure, heart rate and body weight.

OTHER RELEVANT

1. Pair real treatments with accurate, specific expectations

Because expectation adds to the effects of active drugs and protocols, learning what a legitimate treatment is meant to do may amplify its benefit. Some researchers, including Kaptchuk, argue placebo effects should be harnessed as treatments in their own right.

2. Do not expect belief to cure structural disease

Mind-body practices that lower stress and improve sleep can support cancer outcomes through known biology, but expectation alone does not shrink tumors or restore airway function. Use beliefs to ease discomfort, not to replace effective medicine.

3. Watch the mindset you bring to food and movement

The milkshake and housekeeper studies suggest that viewing food as satisfying and daily activity as real exercise can shift hunger hormones and health markers. These are low-cost changes in framing worth applying on purpose.

4. Read this as an argument for better trial design

Placebo controls exist because expectation strength varies between people and contexts. When judging a supplement or drug claim, ask whether it beat a well-designed placebo rather than relying on how it felt.

The Causes & Treatments for Autism | Dr. Karen Parker

Guest: Dr. Karen Parker
Date: 2023-12-11 · Duration: 2:56:28
URL: https://www.youtube.com/watch?v=ccrbE0QHy94

KEYPOINTS

1. Autism prevalence is now about 1 in 36 U.S. children
Parker, a Stanford researcher, says the rate rose from 1 in 44 just a couple of years earlier. She calls the increase multifactorial: more awareness and routine early screening explain part of it. Autism is male-biased, and it is highly heterogeneous: 'If you've met one kid with autism, you've met one kid with autism.'

2. Diagnosis rests on two core features
Under the DSM-5, an expert (usually a psychiatrist or psychologist) looks for pervasive social interaction challenges and restricted, repetitive behaviors. Many autistic people also have anxiety, sensory challenges, seizures or sleep disorders. For most people, autism has lifelong impact, though some outgrow the diagnosis and some respond well to behavioral therapy while others see minimal benefit.

3. Genes matter a lot, and traits run on a continuum
Parker estimates that about 40–80% of autism is genetic, with roughly half linked to common genetic variants. Younger siblings of autistic children are at higher risk, which researchers use in prospective 'baby sib' studies. Autistic traits measured by the Social Responsiveness Scale or Autism Quotient are spread through the general population. They are higher among people in intense STEM fields, even without a diagnosis.

4. Environmental risk factors interact with biology
Associated risks include factors such as maternal illness during pregnancy. These come mainly from large epidemiological studies, since experiments in developing children are rarely possible. Huberman raises Pasko Rakic's mouse work linking repeated prenatal ultrasound to neuronal migration errors. Huberman emphasizes 'perhaps' and notes that the idea never gained traction.

5. Only two drugs are FDA-approved for autism, and both are antipsychotics
They treat associated features like irritability rather than core social symptoms and carry side effects like weight gain. That gap is why Parker focuses on neuropeptides that regulate social behavior: oxytocin and vasopressin, which are ancient, evolutionarily conserved molecules made in the hypothalamus.

6. Oxytocin may help a subgroup, not autism in general
In a study of about 200 children (autistic, unaffected siblings and controls), lower blood oxytocin tracked greater social difficulty in all groups, but it did not separate autism from non-autism. In Parker's double-blind trial with child psychiatrist Antonio Hardan, children given oxytocin twice daily for four weeks benefited if they started with low oxytocin. A later multi-site phase 3 trial found no overall benefit. Parker thinks measurement problems may have obscured a responsive subgroup, and she notes that pediatric oxytocin has looked relatively safe.

7. Vasopressin looks like the stronger bet
Parker says that if she had to bet, she'd bet on vasopressin. In rhesus monkeys at the UC Davis primate center, naturally 'low social' monkeys, which she stresses don't have autism, could be classified almost perfectly by vasopressin in cerebrospinal fluid (CSF), though not in blood. Levels were stable within individuals over time, a requirement for a biomarker. In autistic children, CSF vasopressin tracked social symptom severity but not repetitive behavior.

8. Low CSF vasopressin appeared before symptoms
In banked newborn CSF samples, infants who were later diagnosed with autism already had low vasopressin, while oxytocin didn't differ. The samples came from John Constantino, whose team traced about 2,000 paper records. Parker emphasizes it was a small sample that needs replication. She speculates that many susceptibility genes might converge on a few pathways, vasopressin among them.

9. The vaccine–autism idea is not supported
Parker says the original study was debunked: its author lost his medical license over fabricated data and the paper was retracted. Every study she knows of finds no link between vaccination and autism. Most scientists and doctors she knows vaccinate their own children.

EXAMPLES

1. First vasopressin treatment trial in autistic children
In a randomized, double-blind, placebo-controlled trial (17 children on drug, 13 on placebo), intranasal vasopressin twice daily for four weeks improved social abilities on three measures: parent report, clinician evaluation and lab tests. A subset also showed less anxiety and fewer repetitive behaviors. Parker warns that dosing matters and adverse effects could be severe, so no one should try it outside a trial.

2. Voles and day length
Monogamous prairie voles bond and co-parent, unlike meadow voles, where mothers raise pups alone. Parker noticed that male meadow voles housed on winter-like day lengths began hanging out with females and helping with litters. That observation drew her into vasopressin and social behavior.

3. Probiotics in mouse models
In genetically modified mice with social impairments and low oxytocin, giving a probiotic normalized social behavior and raised hypothalamic oxytocin, and in one study vasopressin too. Cutting the vagus nerve blocked the rescue, which shows

the effect runs from gut to brain through the nerve. These are animal findings.

4. Why primate models matter

Thalidomide, a morning-sickness drug, had its toxicity testing done only in mice. Children were then born with severe limb abnormalities. When it was later tested in primates such as marmosets, the defects appeared, and Parker notes that even a single primate test might have prevented the harm. MPTP, the synthetic heroin that caused overnight parkinsonism in people, also had little effect in mice. Monkey social behavior, including affiliative gaze and grooming, maps onto human behavior in ways mouse behavior doesn't.

OTHER RELEVANT

1. Early behavioral intervention still matters

Diagnosis can wait 12–18 months at clinics during critical early windows. That is why Parker wants faster lab-based screening tests, such as blood or CSF biomarkers. Evaluation should come from qualified experts, not self-diagnosis.

2. Neuropeptide treatments need a prescription and trial evidence

Oxytocin spray requires a physician's prescription and isn't approved for autism. Vasopressin results come from a small trial that is being extended to larger groups. Parker suggests stratifying patients by baseline levels.

3. Funding delays have costs

Huberman notes that three to five years of grant writing can stand between a sound hypothesis and a trial, while children age through critical developmental windows.

Curing All Human Diseases & the Future of Health & Technology | Mark Zuckerberg & Dr. Priscilla Chan

Guest: Mark Zuckerberg & Dr. Priscilla Chan
Date: 2023-10-23 · Duration: 2:15:32
URL: https://www.youtube.com/watch?v=1Wo6SqLNmLk

KEYPOINTS

1. CZI's goal: help science cure, prevent or manage all disease by 2100
Chan, a physician and educator, frames the Chan Zuckerberg Initiative (launched in 2015) as a bet on basic science rather than on any single disease. CZI does three things: funds scientists, builds software tools and runs its own science through 'Biohubs'. Both stress that CZI won't cure disease itself. Its goal is to speed up the whole field, and its funding is a small fraction of what the NIH spends.

2. New tools usually come before big discoveries
Zuckerberg says their reading of the history of science is that major breakthroughs tend to follow a new way of seeing, such as the telescope or microscope. He argues the next ten years should mainly go to measuring and observing human biology, comparing it to debugging code: you can't fix a codebase you can't step through, and at Meta big projects start with instrumentation.

3. The cell sits between a genetic typo and the disease
Chan's analogy is a recipe with a typo that produces a bad cake: we know the typo (the mutation) and the result (the disease), but not how the chef and oven, the cell's mRNA, turned one into the other. Single-cell work studies how each of the body's roughly 37 trillion cells reads the same DNA differently in health and in disease.

4. Cell atlases plus AI could produce a 'virtual cell'
Since CZI funded methods work in 2017, near-complete single-cell atlases of humans, flies and mice have emerged, far too much data for people to interpret. Large language models (based on the Transformer architecture) are pattern-recognition machines that work on more than words. Trained on cell-atlas data, a model given a cell's state could predict its next states, much as AlphaFold did with protein folding.

5. In-silico experiments still have to be checked in humans
Chan welcomes cheap, fast computer experiments but warns that 'we've basically cured every single disease in mice'. Model systems are relevant but not one-to-one with humans, so predictions must be confirmed in human biology.

6. Biohubs require collaboration across institutions
Proposals had to involve at least three institutions and several disciplines. The call drew 57 proposals from over 150 institutions. Each Biohub has about 50 dedicated staff, independent of the universities, while letting faculty contribute without leaving their posts. CZI runs in five-year cycles: try many models and double down on what works.

7. Chicago Biohub: sensors inside engineered tissue to catch inflammation early
The University of Illinois Urbana-Champaign, University of Chicago and Northwestern are embedding ultra-thin sensors in lab-engineered skin to read what cells secrete and when inflammation starts. Chan notes inflammation drives about 50% of all deaths. They're also studying the neuromuscular junction, whose slowing with age helps explain why older people fall.

8. New York Biohub: immune cells engineered to act as internal microscopes
Zuckerberg calls it a 'cellular endoscope'. The plan is to engineer immune cells that travel to tissues such as coronary arteries, record whether plaque is present and report back, then eventually engineer cells to clean it up. Targets include places the immune system rarely reaches, such as ovarian and pancreatic cancer and neurodegenerative disease. They describe it as a 10–15-year project.

9. CZI leaves drug development to others but backs rare-disease groups
CZI doesn't develop therapeutics itself, though some Biohub teams have spun out startups. Its Rare As One program funds patient advocates to build registries and recruit researchers and drug developers. Chan stresses that 'rare diseases aren't rare': there are over 7,000, and each offers a window into how normal biology works.

10. Social media is best for connection, worst as negative passive scrolling
Zuckerberg separates interacting with people, which he associates with well-being, from passive consumption, which is at best entertainment and at worst relentlessly negative news. Meta defaults under-16 accounts to private and offers parental tools, time-use tools and nudges when teens get stuck on one type of content. He says Meta has at times been 'too paternalistic' about deciding what content is good for people.

EXAMPLES

1. Single-cell methods reshaped the picture of cystic fibrosis
Cystic fibrosis was taught as a CFTR channel defect that impairs mucus clearance. Single-cell analysis of the lung found an entirely new cell type affected by the CF mutation, which Chan says changed how the disease is understood.

2. CELLxGENE: type in a gene, see where it's active
CZI's free tool shows a heat map of which cell types express a gene and pulls up the most relevant papers. A heart researcher might discover the gene also spikes in the pancreas, which suggests new hypotheses, collaborations and possible drug side effects.

3. How Meta reduced clickbait
People clicked on clickbait but then barely read it and didn't report good experiences. Meta adjusted its ranking using usage

signals plus panels of real people rating which stories they found meaningful.

4. Huberman's mixed-reality boxing session

Huberman, who says he hates screen-based workouts, found a mitt-boxing class in the headset engaging enough to forget it was virtual, because he could still see the physical room.

5. Ray-Ban Meta glasses and the privacy light

The second version has a camera about twice as good, crisper audio for calls and podcasts, and a built-in AI assistant. Asked about recording in places like locker rooms, Zuckerberg says the right test is whether a technology makes misuse easier than existing tools. A pulsing white light shows when the camera is on, which he argues is more visible than someone pretending to text while filming.

OTHER RELEVANT

1. Use the safety tools you already have

Huberman, who was surprised by how many filters exist, recommends Instagram's 'restrict' function over blocking in most cases, and Adam Mosseri's weekly Q&As for learning about features. Zuckerberg says most of this education has to happen inside the product, when the relevant moment comes up.

2. Notice your feed's 'gravitational pull'

Huberman compares some content, such as street-fight clips, to highly processed food: engrossing at the moment but leaving you no better off. Animal content, by contrast, leaves him energized. Zuckerberg says the algorithm tries to weigh long-term wants over short-term loops.

3. AI versions of real people should be controlled by them

Zuckerberg says Meta bans impersonation and that any creator's AI assistant should be under that creator's control, because current models can't yet guarantee faithful representation. Meta started instead with fictional personas, such as a chef, fitness guides and Snoop Dogg as a dungeon master he uses for bedtime stories with his daughter.

Life, Death & the Neuroscience of Your Unique Experience | Dr. David Linden

Guest: Dr. David Linden
Date: 2023-08-21 · Duration: 2:36:47
URL: https://www.youtube.com/watch?v=29n0WG317tM

KEYPOINTS

1. Krause corpuscles are finally confirmed as the nerve endings for sexual touch
German anatomist Krause described these endings in the penis and clitoris in 1860. They also appear in the nipples, lips, cornea and joint linings, so their role was never clear. A preprint from David Ginty's lab at Harvard showed in mice that they're mechanical sensors. Switching them on with light-activated (optogenetic) tools caused erections, and switching them off reduced mounting and ejaculation in males and receptivity in females.

2. Sexual sensation may vary between people and fade with age
Linden speculates that individual differences in Krause corpuscle structure might help explain why people like different kinds of touch, and that their loss with age could parallel the known age-related loss of fine-touch endings (Merkel and Meissner) in fingertips. He notes that chronic masturbation is known to desensitize the penis, which is more likely a change in receptor function than in structure.

3. Smell is where humans differ most, and it's highly suggestible
We have about 400 functional odor receptors, and any two people differ in about 30% of them (work by Leslie Vosshall's group at Rockefeller). Androstenone smells like nothing, grass or urine depending on a single receptor gene. Linden calls humans the 'anti-pandas': we live everywhere and eat everything, so few smells are innately aversive (exceptions include the rotting-meat compounds cadaverine and putrescine), and most smell preferences are learned culturally.

4. Perception is inference
Linden's broader theme is that no sense delivers an objective world. Smell, taste, sight, balance and fullness are all shaped by experience, expectation and context, which makes it 'almost a miracle' that we agree on a shared reality at all.

5. Early-life experience can set traits that look genetic
Children who spend little time outdoors in their first five years or so are more likely to become nearsighted, because light appears to drive growth factors that control how much the eyeball elongates. Linden calls this 'news you can use': get kids outside. Heat tolerance is another example (see below).

6. Most traits are partly heritable, and heritability depends on circumstances
Wet versus dry earwax (the ABCC11 gene) is 100% heritable, while accent is 0% heritable and comes mainly from peers. Height is about 85% heritable in the US but only about 50% in rural Bolivia or India, where poor nutrition and disease keep people from reaching their genetic potential. IQ shows the same pattern: roughly 60–70% heritable in affluent settings and lower where schooling and care are poor. 'Genes don't code for traits, they code for proteins.'

7. Family environment explains surprisingly little of personality
In the Minnesota Study of Twins Reared Apart, the 'Big Five' personality traits were about 50% heritable, but family upbringing contributed almost nothing to the rest. Linden attributes much of the remainder to the random nature of development: the genome isn't a wiring diagram for trillions of connections. Parents still shape values, religion and career choices.

8. Inheriting trauma through DNA marks across generations isn't proven in mammals
It has been shown convincingly in worms and plants. The human evidence comes largely from famine records in Överkalix, Sweden, which Linden criticizes for having no known mechanism and for running many comparisons without correction (hypothesizing after the results are known). 'You may well inherit your grandma's trauma, but probably socially.' Effects within a single pregnancy are better established.

9. Inflammation and depression are linked, but simple fixes haven't worked
About a third of people with depression benefit significantly from SSRIs, a third slightly and a third not at all. An inflammatory cytokine once used to treat hepatitis C made nearly everyone depressed, and multiple sclerosis (with high IL-6) carries far more depression than spinal cord injury does. Yet giving anti-inflammatory drugs to depressed people in general hasn't helped. There are hints they may help SSRI non-responders, but the evidence is 'right on the edge'.

10. Mind-to-body effects need clear biological pathways
Nerves that grow into melanomas release CGRP, which suppresses the immune cells attacking the tumor and worsens prognosis. Linden floats, and labels as without evidence, the hypothesis that meditation could slow such tumors through a defined neural pathway. He argues researchers should take mind-body claims back from 'nonsense' by testing them rigorously. Breathing rhythms show up throughout the brain, which makes effects of breathwork plausible.

11. The cerebellum predicts the next second or two
The cerebellum is known for motor coordination; damage causes clumsiness and overshooting, not paralysis. Through connections to the thalamus and frontal cortex, its predictive computation also supports social judgments, such as whether someone is a friend or a threat, and other non-motor tasks.

EXAMPLES

1. Japanese soldiers' heat stroke in WWII
Soldiers from cold Hokkaido collapsed from heat far more often than those from subtropical Kyushu. Both groups had the same number of eccrine sweat glands, but southerners had more of them connected to nerves. Children of northern families raised in the south developed the southern pattern, and vice versa: an adaptation set within one lifetime by early experience.

2. Parmesan or vomit?
The same butyric/isovaleric acid mixture is identified as parmesan or as vomit depending on the label, per research Linden credits to Rachel Herz, and people refuse to believe it was the same vial.

3. The 1918 flu and later schizophrenia
Men who were in the womb during the 1918 pandemic were a millimeter or two shorter, and rates of schizophrenia and what we'd now call autism rose about fourfold. Gloria Choi at MIT modeled this in mice: mimicking a viral infection during the first-trimester equivalent triggers an IL-17 surge (interacting with gut bacteria) that crosses the placenta and disorganizes the layers of the developing cortex.

4. Linden's heart cancer
In 2020, breathlessness led to treatment for atrial fibrillation, then the discovery of a Coke-can-sized mass pressing on his heart, and two-day open-heart surgery. It turned out to be synovial sarcoma of the heart, rare enough that only individual case reports exist. Given 6–18 months, he was still alive about 27 months later at the time of this conversation, aged 61.

OTHER RELEVANT

1. You can feel grateful and furious at the same time
Linden was 'white-hot angry' at the diagnosis and deeply grateful for his life in the same moment, which overturned his idea of emotion as a single scale. His gratitude is for 'the very biggest things' (being conscious, following his curiosity, his wife and children), not for small details.

2. Curiosity as agency during illness
During chemotherapy he couldn't talk himself out of low mood, probably because his brain was 'awash in interleukin-6', but noticing that as a scientist gave him a sense of agency. He recommends this 'way of the nerd' only for naturally curious people.

3. Context changes how much time feels like enough
Five years would have seemed a tragedy before diagnosis and a gift after it. Linden argues that because the brain constantly predicts the near future, it can't truly imagine its own absence, which he suggests is why almost every religion has some form of afterlife.

4. Career and life advice
Linden warns that today's hot technique (single-cell profiling) will be passé by the time a five-year PhD is finished, and agrees with the 'deletion test' Huberman credits to Stanford's E.J. Chichilnisky: if others already do something well, pick something else. His universal advice: 'appreciate what you got while you got it.'

How Smells Influence Our Hormones, Health & Behavior | Dr. Noam Sobel

Guest: Dr. Noam Sobel
Date: 2023-05-01 · Duration: 3:13:16
URL: https://www.youtube.com/watch?v=cS7cNaBrkxo

KEYPOINTS

1. Humans have a remarkable sense of smell
Sobel, an olfaction researcher at the Weizmann Institute, pushes back on the idea that humans smell poorly. We detect mercaptan, the sulfur additive that gives cooking gas its smell, at about 0.2 parts per billion, which no machine matches well. He also notes that we smell through the mouth (retronasal olfaction) as well as the nose. He points out that a widely repeated claim about a billion receptors in a bloodhound's nose turned out to be made up.

2. Smell loss: training has better evidence than supplements
Olfactory neurons regenerate. But if a head injury completely severs the olfactory nerve at the cribriform plate, smell is lost for good. Sobel's rule of thumb for viral loss, including COVID, is that if smell hasn't returned within about a year to a year and a half, it probably won't. Because olfaction is 'use it or lose it', smell-training programs have strong evidence, more than alpha-lipoic acid, for which the evidence is 'not overwhelming'.

3. Not all 'smells' are olfactory
The trigeminal nerve also has endings in the nose and throat, so sharp sensations like lemon can come through it even when true smell is gone. 'Pure olfactants' such as coffee and vanilla stimulate only the olfactory nerve. They are a better test of whether real smell has come back.

4. The nasal cycle tracks your autonomic state
One nostril usually flows more than the other, and dominance alternates about every 2.5 hours on average. The switch becomes very pronounced in sleep. It is driven by the balance of sympathetic and parasympathetic activity. Sobel's lab built a 24-hour wearable 'nasal Holter' that logs each nostril's flow separately. From those recordings alone, they can tell adults with ADHD from those without, and whether they're on Ritalin.

5. Inhaling through the nose shapes cognition
Sobel's theory is that because the mammalian brain evolved around sniffing, with information arriving in bursts on each sniff, nasal inhalation came to time neural processing in general. In his lab, people performed a visuospatial task significantly better when trials started on inhalation than on exhalation. He and Huberman favor nasal over mouth breathing whenever possible.

6. Smell loss is an early sign of neurodegeneration
Smell loss is not diagnostic on its own, because there are many causes. But a large decline, such as smell becoming 50% worse within a year, is a bad sign for Parkinson's or Alzheimer's risk. Olfactory neurons are the one place the brain directly touches the outside world. Sobel says smell tests haven't become routine screening mainly because smell hasn't been effectively digitized.

7. We constantly sniff ourselves and others, mostly without knowing it
Sobel believes nearly all of our chemical social sensing is subconscious. People sample their own body odor all day and appear to compare it with others' odor.

8. Humans may lack a working vomeronasal organ, but chemosignals still work
In mice, the Bruce effect, named for the British scientist who described it in 1959, makes a recently mated female miscarry on about 80% of exposures to an unfamiliar male's odor. The human vomeronasal (Jacobson's) organ is considered vestigial, though Sobel isn't convinced it is completely non-functional. Human chemosignaling clearly exists through other routes.

9. Menstrual synchrony findings are contested
Martha McClintock published menstrual synchrony in Nature in 1971 as an undergraduate, then a 1998 follow-up showing that odors collected at different cycle phases had opposite effects on cycle length. Sobel notes that the findings were later widely questioned, partly because statistics on cyclic events are tricky.

EXAMPLES

1. The handshake study
Participants were secretly filmed in a waiting room before and after an experimenter came in and either shook their hand or didn't. After handshakes, people brought their hands to their noses and sniffed them, which nasal-airflow measurements confirmed. An odor-emitting 'James Bond' watch on the experimenter's hand altered how much people sniffed afterward. Sobel questions the popular 'show you hold no weapon' explanation for handshakes.

2. 'Click' friends smell alike
Same-sex, non-romantic friends who clicked instantly were more similar in body odor than random pairs, measured both by an electronic nose and by human smellers. In a nonverbal mirror game, body-odor similarity predicted which strangers would rate each other as likely friends. It did not predict how well they mirrored each other.

3. Repeated pregnancy loss and body odor
Most women identify their spouse's body odor at near chance. Women who had experienced repeated spontaneous pregnancy loss did more than twice as well, without being better at other odors. Brain imaging showed altered responses to unfamiliar men's body odor. Causation is unknown, and a causal trial is just beginning.

4. Hexadecanal, a baby-head odor molecule
In a well-validated aggression game against a computer opponent programmed to be a 'jerk', the barely smellable molecule

hexadecanal reduced aggression in men and increased it in women. Brain connectivity from the angular gyrus to aggression circuits explained the split. The insight was that babies benefit from both effects: less paternal aggression and more protective maternal aggression. Hexadecanal was later found in emitted baby-head odor.

5. Women's emotional tears

Tears from women who cry easily while watching films like 'The Champ' were collected. Recruiting produced about 100 women and one man. Sniffing the tears produced a drop of about 14% in men's free testosterone and dampened hypothalamic activity. Unpublished data under review suggest that it also lowers men's aggression.

OTHER RELEVANT

1. If you lose smell, train it

Smell a set of distinct odors daily. It's cheap and better supported than supplements. Test recovery with pure olfactants like coffee or vanilla rather than with sharp scents.

2. Notice big changes in smell

A sharp drop in smell over a year is worth raising with a doctor, especially with other risk factors. Don't panic about one bad day.

3. You can learn to scent-track

Blindfolded, ear-plugged, gloved people could follow an odor trail laid with scented twine buried in grass right away. After about 4 days of training, crawling speed was the only limit. Two nostrils helped. Sobel also reports that none of the 14 yogis who claimed willful nostril switching could actually do it.

Neuralink & Technologies to Enhance Human Brains | Dr. Matthew MacDougall

Guest: Dr. Matthew MacDougall
Date: 2023-04-17 · Duration: 2:01:41
URL: https://www.youtube.com/watch?v=3ZGItIAUQmI

KEYPOINTS

1. The brain is a set of functional modules
MacDougall, Neuralink's head neurosurgeon, who trained at UC San Diego and Stanford, says watching a small tumor knock out one discrete function shows the brain is a collection of modules 'duct-taped together' in a bone box. Hormones, vision, sensation and movement can each fail independently.

2. The frontal lobes act as a filter on impulses
Rather than simply suppressing impulses, the frontal lobes let them through under control, like 'you can have it if you pay for it first'. MacDougall recalls a young car-crash patient with damage to both frontal lobes who, after surgery, openly propositioned his 80-year-old recovery nurse.

3. Deep brain structures are 'firmware'
Regions governing body temperature, blood pressure, hunger, sex and sleep are similar across species and more predictable when damaged or stimulated. The neocortex, the part that reasons and problem-solves, differs vastly between a fox and a human. One odd example: hypothalamic tumors in children can cause gelastic seizures, bouts of joyless laughter that have occasionally been fatal.

4. Laser ablation is changing tumor surgery
Through a 2 mm hole in the skull, surgeons pass a fiber-optic probe and heat a deep tumor while monitoring its temperature under real-time MRI. Tumors in the brainstem, motor cortex or Broca's area, once inoperable or catastrophic to remove, can now sometimes be eliminated with almost no aftereffects.

5. MacDougall thinks drugs will beat electrodes for boosting plasticity
Plasticity declines with age. Because broad rewiring means changing trillions of synapses at once, he thinks drugs such as psychedelics will do more than any electrode he expects to see in his lifetime, which is surprising coming from Neuralink's surgeon.

6. Neuralink's first goal is restoring 'digital freedom'
Threads thinner than a human hair, placed by a robot, would record from the intact motor cortex of people with high spinal cord injuries so they can control a cursor and keyboard by intention alone. Robots are needed because no human hand is steady enough to place micron-scale loops among densely packed surface blood vessels. A later goal is a spinal implant to bypass the injury and reconnect brain to body.

7. Decoding relies on smart software and patients who give feedback
Software adapts to the brain's firing patterns while the user learns the device. Neuralink holds the record bit rate for monkeys controlling a cursor, which MacDougall credits partly to Krishna Shenoy's lab. Human volunteers can say what they're trying, and Stanford work (Shenoy, Jaimie Henderson) has even decoded speech from the hand area.

8. MacDougall argues bit rate is the yardstick for brain interfaces
Like a modem's speed, the key number is how much useful information a device can move into or out of the brain. Wearables such as Neosensory's sound-to-touch wristband are easy to adopt but have low ceilings. Implants could in principle reach millions of neurons.

9. MacDougall says alcohol is the most common brain damage people choose
He says his patients near San Francisco's Tenderloin who've been heavy drinkers for years show brains 'like small walnuts' on scans. Huberman cites UK brain-imaging data showing near-linear thinning of gray matter with each additional weekly drink. MacDougall would like people to be far more wary of it.

10. The skull's one design flaw
The temple bone is among the thinnest in the skull, and the middle meningeal artery runs right beneath it, a feature surgeons call 'God's little joke'. A focused blow can fracture the bone and tear the artery, causing an epidural blood clot that crushes the brain. Fluid around the brain otherwise cushions it well.

11. Why some brains survive big lesions and others don't
MacDougall says species, age and redundancy explain the contradiction. Removing half the brain of a very young baby can still allow high function because the remaining half takes over. Adult humans, by contrast, lose discrete functions such as speech, finger control or part of vision from small lesions.

12. MacDougall's long-term vision
Within 10–20 years he hopes to tackle addiction, depression, suicide and obesity as brain malfunctions. For his children's generation he imagines cognition merged with AI and communication freed from the narrow 'flapping air past meat' bottleneck of speech. Texting by thought, he notes, is mostly an engineering problem rather than a neuroscience one.

EXAMPLES

1. An RFID chip in his hand
MacDougall implanted a passive glass RFID tag between his thumb and forefinger at his kitchen table, coated in extra silicone because he rock-climbs. It opened his front door and Neuralink's doors, and once stored a crypto wallet key that had gained a few thousand dollars when he remembered it. His wife later asked for one, and they consider them their wedding rings.

2. He'd take a Neuralink implant himself
MacDougall says yes, though the first version wouldn't help an able-bodied person. He believes the procedure is already safer than many standard FDA-approved surgeries he performs.

3. No water deprivation for the monkeys
Many labs motivate animals by restricting water. MacDougall says Neuralink monkeys like 'Pager' have full food and water and play games for smoothie treats only if they want to. Pigs serve as a skull-sized platform for testing safety.

4. Bluetooth headphones
MacDougall uses them and says their power levels are far too low to worry him, compared with the background radiation we're all exposed to.

OTHER RELEVANT

1. Protect your brain with the basics
Avoid head injuries and especially a second one, get any head injury treated, and cut back on alcohol. Huberman notes we don't yet know what chronic stimulant use (Adderall, modafinil) does to the brain.

2. Drowsy driving is a major risk
Huberman's reading of the data is that reduced alertness contributes to about a third of vehicle accidents. MacDougall notes that Tesla's cabin camera already tracks whether drivers' eyes are on the road.

3. How to take part
At the time, Neuralink was still working toward FDA approval and kept a patient registry for people with quadriplegia interested in future trials.

Genes & the Inheritance of Memories Across Generations | Dr. Oded Rechavi

Guest: Dr. Oded Rechavi
Date: 2023-02-27 · Duration: 2:32:01
URL: https://www.youtube.com/watch?v=CDUetQMKM6g

KEYPOINTS

1. Whether acquired traits can be inherited has a troubled history
Rechavi, who studies inheritance in worms, traces the idea's bad reputation to the early 1900s. Paul Kammerer claimed that midwife toads trained to breed in water developed dark mating pads (nuptial pads) and passed them to their offspring. The specimens turned out to have been injected with ink, and the scandal tainted the field for decades.

2. The 'memory transfer' experiments of the 1960s–80s collapsed
American psychologist James McConnell trained flatworms (planaria) to avoid shocks, then reported that worms regrown from cut-off tails kept the memory, and that untrained worms fed ground-up trained ones learned faster. Similar brain-transfer experiments followed in goldfish and rodents. Nobody could replicate the results reliably and the field ended in what Rechavi calls a catastrophe, though the idea of a memory in molecular form remains appealing.

3. Two barriers should stop experience from reaching the next generation
The first is the Weismann barrier, proposed by August Weismann in the 19th century and called the 'second law of biology': only germ cells (sperm and eggs) carry information forward, and they are kept separate from the body's other cells. The second is epigenetic reprogramming: about 90% of the chemical marks on DNA are wiped clean in sperm, eggs and the early embryo. Rechavi says 'epigenetics' is a heavily misused word, even by scientists.

4. In mammals there is evidence of effects across generations, but the mechanisms are unclear
Children of women who were starved during pregnancy in famines in the Netherlands, China and Russia showed differences in birth weight, glucose sensitivity and risk of some neurological diseases. Rechavi stresses that for most such effects the mechanism is still unknown, and that in mammals no system has been found that amplifies inherited RNA.

5. C. elegans worms pass small RNAs to their offspring
This tiny worm always has 959 cells, 302 of them neurons, each with a known name. Andrew Fire and Craig Mello won the 2006 Nobel Prize for showing that double-stranded RNA silences matching genes (RNA interference). Worms have no T or B cells and fight viruses with these small RNAs.

6. Without amplification, inherited RNA would dilute away within a few generations
Each worm has about 250 offspring, so after four generations any molecule from the original parent would be diluted about four-billionfold. An enzyme called RNA-dependent RNA polymerase recopies the small RNAs in every generation, which keeps them from running out. Effects typically last three to five generations, and his lab found 'MOTEK' genes that act as a clock setting how long the inheritance lasts.

7. Specific learned memories probably can't be inherited, but simpler states might be
Rechavi doubts that arbitrary memories stored in brain wiring, such as this conversation, could pass to children: even identical twins wire their brains differently. Simpler changes might pass on, for example a learned aversion that works by removing the receptor for one odor, which a single RNA could in principle control. That hasn't been shown convincingly in worms.

8. Germ cells can change behavior through the body
Germ cells secrete signals that shape the rest of the body and brain. Huberman describes his dog regaining his old personality on testosterone therapy. In mammals, small RNA changes in germ cells could alter very early development or the placenta and cascade into later metabolic problems.

EXAMPLES

1. Virus immunity inherited without the genes to make it
Working in Oliver Hobert's lab, Rechavi infected worms with a virus engineered to glow green when it replicates. The worms destroyed it. He then bred descendants that couldn't make small RNAs themselves, yet they still silenced the virus for several generations using RNAs inherited from their ancestors.

2. Starved and stressed parents
Starving worms affects their descendants for a few generations, and those descendants live longer, though he warns this could be a trade-off rather than an adaptation. In Isabelle Mansuy's mouse work, sons of stressed fathers showed less anxiety but had memory deficits. In Oliver Rando's work, offspring of nicotine-exposed rodents tolerated nicotine and other drugs better.

3. Heat-stressed parents and mate choice
C. elegans hermaphrodites usually fertilize themselves, and mating with rare males is costly. When hermaphrodites were stressed with heat, their descendants mated far more with males for about three generations. Disrupted small RNA inheritance impaired their sperm, so they released a pheromone that drew in males.

4. Cold makes worms remember far longer
His student Dana, skipping the experiment he'd assigned, put worms on ice after teaching them an association. They held the memory about 10 times longer. Worms first acclimated to cold forgot quickly, which showed that internal state, not just temperature, controls forgetting. The genes responsible act in a single pair of neurons, the only ones in the worm sensitive to lithium, a long-used treatment for bipolar disorder.

OTHER RELEVANT

1. Some inherited effects may be reversible

In rodent studies, overfeeding parents harmed their offspring, but letting the parents exercise corrected it. Rechavi expects the nearer-term use to be diagnostics: testing the RNA in sperm or eggs, much as DNA screening is already offered to most couples in Israel.

2. Mitochondrial replacement ('three-parent IVF')

The nucleus from a mother's egg is moved into a donor egg with healthy mitochondria, then fertilized. Huberman notes it is illegal in the U.S. but has been done several times elsewhere for mitochondrial disease. Whether the children will grow up healthy is still unknown.

3. Emotional arousal acts like a highlighter pen

Huberman connects the cold result to the medieval practice of throwing children into cold water to make lessons stick, and to adrenaline, which strengthens memory after important events. Rechavi wants to know whether such state switches depend on RNA.

The Science of Learning & Speaking Languages | Dr. Eddie Chang

Guest: Dr. Eddie Chang
Date: 2022-10-24 · Duration: 2:34:24
URL: https://www.youtube.com/watch?v=Z7MU6zrAXsM

KEYPOINTS

1. The sounds of early life shape the hearing brain
As a medical student working with Mike Merzenich at UCSF, Chang raised rat pups in continuous, moderate white noise that masked natural sounds. The critical period of the auditory cortex stayed open months longer than normal. That sounds like a benefit, but it actually meant delayed maturation. Humans have a similar window: within a couple of years, infants lose sensitivity to speech sounds outside their native language.

2. White noise machines for babies are an open question
Asked whether white noise harms infants' hearing development, Chang says the studies haven't been done. He has used soothing tools himself with three kids. His caution is that continuous white noise doesn't occur in nature, and the developing brain seems to need structured, meaningful sounds.

3. Electrical stimulation of brain areas can switch anxiety on or off
During awake brain mapping, stimulating the orbitofrontal cortex reduced stress, but only in patients who were already anxious. Stimulating the amygdala could cause sudden anxiety, and stimulating the insula could cause disgust. Chang suspects some psychiatric conditions reflect imbalances in electrical activity across these areas.

4. Epilepsy often resists medication
About a third of people with epilepsy (defined here as three or more seizures) aren't controlled by modern drugs. If two or three medications have failed, a fourth or fifth rarely helps. A subset can benefit from surgery to remove the seizure source or from implanted stimulators.

5. The textbook map of language areas is partly wrong
The textbooks still assign speaking to Broca's area (based on Broca's 19th-century patient 'Tan') and understanding to Wernicke's area in the left temporal lobe. In hundreds of patients, Chang's team found that surgery on the posterior frontal lobe often leaves speech intact. The speech-motor areas of the precentral gyrus, which control the lips, jaw and larynx, matter more for producing words. He estimates that about 50% of what's taught about the brain is accurate and the rest oversimplified.

6. Which side of the brain handles language depends partly on handedness
In right-handed people, language is on the left side 99% of the time. In left-handed people it's about 70%, with 20–30% using both sides or the right. After a left-sided stroke, nearby tissue or even the right hemisphere can take over. Chang thinks both sides have the machinery but the brain specializes one.

7. Speech cortex has a 'salt-and-pepper' map of sound features
Recording directly from the brain surface at millimeter and millisecond resolution, his lab finds sites tuned to features such as plosives (b, d, g, made by closing and releasing the mouth) and fricatives (sh, th, made by air turbulence). These sites are scattered rather than laid out in an orderly map. Speech may also reach the speech cortex by its own route, bypassing the primary auditory cortex, which is ordered by frequency.

8. About a dozen movements build every word
Speech production comes down to roughly 12 movement features of the tongue, jaw, lips and larynx. Each is meaningless alone, but combined in sequence they generate every word, which Chang compares to DNA's four bases encoding life.

9. Reading is borrowed from older brain systems
Writing is too recent to have evolved its own brain area. Instead, a visual word form area at the back of the temporal lobe is recruited and linked to the speech-sound system. Many cases of dyslexia stem from weak phonological awareness, a mismatch between seen words and their sounds, rather than purely a visual problem.

10. Bilingual speakers use overlapping circuits
In Chang's ongoing lab study, the same speech areas respond to both languages, and the 'English' cortex even tries to parse an unfamiliar language. What differs is the stored memory of sound sequences that make up each language's words.

EXAMPLES

1. Anxiety that turned out to be seizures
A young woman was treated for anxiety disorder for years. The clue was that her panic attacks came out of nowhere, with no trigger. Her MRI was normal, and only electrodes placed in the brain proved the attacks came from seizures in her amygdala. She needed awake surgery. Chang stresses that the vast majority of anxiety is not caused by seizures.

2. Pancho and the BRAVO trial
The first participant was a man who'd had a brainstem stroke around age 20, days after a car accident, and had not spoken for 15 years. Electrodes over his speech-motor cortex were connected through a port in his skull. After weeks of training the decoder, he produced sentences from a 50-word vocabulary, helped by an autocorrect-style language model. When he giggled with excitement, it disrupted decoding of the next word.

3. Foreign accent syndrome is real; sudden fluency in a new language is not
Chang has never seen or read of a stroke unlocking a language someone didn't know. He has seen foreign accent syndrome, where damage to vocal-tract control areas makes someone sound as if they have a foreign accent.

4. Decoding speech, then faces

About six years before this conversation, his team could decode every English consonant and vowel from epilepsy patients' brain recordings. The next goal is an animated avatar that conveys a paralyzed person's facial expressions along with text.

OTHER RELEVANT

1. Watch for anxiety that has no trigger

Panic that strikes with no trigger, especially if it doesn't respond to treatment, is worth raising with a neurologist. Seizures may only show up on electrodes, not on an MRI.

2. Stuttering is a coordination problem, often made worse by anxiety

Language is intact, but the precise coordination of the larynx, lips and jaw breaks down at times. Anxiety triggers or worsens stuttering but isn't the cause. Speech therapy helps with starting words, and changing how people hear their own voice can alter stuttering for better or worse.

3. Chang's way of staying calm under pressure

He exercises (running, swimming) mainly for his mind and notices the effect within a day or two of skipping it. He leaves his phone outside the operating room and prefers silence there, treating surgery's routine moments as a focused refuge from outside worries.

The Neuroscience of Speech, Language & Music | Dr. Erich Jarvis

Guest: Dr. Erich Jarvis
Date: 2022-08-29 · Duration: 1:54:20
URL: https://www.youtube.com/watch?v=LVxL_p_kToc

KEYPOINTS

1. There is probably no separate language module in the brain
Jarvis argues speech and language are psychology-derived terms that do not map neatly onto brain function. Rather than a language center instructing other areas, the complex algorithms for spoken language are built into the speech production pathway that controls the larynx and jaw, and the algorithms for understanding speech live in the auditory pathway.

2. Understanding speech is common; producing learned sounds is rare
The auditory perception pathway is widespread in animals, which is why dogs can learn several hundred human words and great apes several thousand, yet cannot say one. The speech production pathway is specialized in humans, parrots, songbirds and hummingbirds, only three of roughly 40-plus bird orders. Koko the gorilla, raised with humans for 39 years or more, learned sign language but could not produce the sounds.

3. Innate vocalizations and learned speech use different circuits
Most vertebrates vocalize, but with innate sounds such as crying or barking controlled by brainstem and hypothalamic circuits. Learned vocalization uses forebrain circuits. In humans and parrots, the forebrain has taken direct control of brainstem vocal circuits, enabling imitation.

4. Songbirds and humans converged on the same circuits and genes
Parallels include critical periods, deterioration of vocalizations after deafness, and homologous areas, such as the robust nucleus of the arcopallium and laryngeal motor cortex. The specialized genes, and even similar mutations, overlap despite a common ancestor 300 million years ago. FoxP2 mutations that cause human speech deficits cause similar deficits when induced in vocal-learning birds. Jarvis thinks spoken language arose in our ancestors within the last 500,000 to 1 million years and that Neanderthals likely had some form of it.

5. Speech circuits switch off repulsion genes and turn on neuroprotection
Jarvis's lab predicted connectivity genes would differ in speech circuits, which have a direct cortical connection to the motor neurons of the larynx or syrinx. Surprisingly, several axon-guidance genes that normally repel connections were turned off, allowing connections that would not otherwise form. Calcium-buffering and neuroprotective genes such as parvalbumin and heat shock proteins were turned up, probably because laryngeal muscles are the fastest-firing in the body, so their control neurons need protection from toxicity.

6. Critical periods are strongest for speech
The whole brain passes through critical periods, but speech has an especially strong one; feral children who pass puberty without language struggle to acquire it. Jarvis's view is that the brain has limited capacity and stability aids survival. Humans carry an extra copy of SRGAP2, which keeps speech and other circuits more juvenile and plastic throughout life than in other animals.

7. Multilingual children keep more phonemes, easing later languages
We are born able to produce many phonemes and narrow them to those our language uses. People who learn several languages early retain more of them, so a third or fourth language is easier, not because of greater plasticity but because the sounds are already available.

8. Only vocal learners dance
Aniruddh Patel and others found that synchronizing body movement to a musical beat is limited to vocal-learning species. Jarvis's motor theory of vocal learning origin holds that speech pathways evolved by duplicating surrounding motor-learning circuits. The tight auditory-motor integration needed for speech then spread to neighboring regions, letting us coordinate whole-body movement to sound. Speech carries more semantic meaning; dance carries mostly affective, bonding communication.

9. Semantic and emotional communication share circuits but differ by hemisphere
Courtship song and meaningful words use the same song or speech circuits, with emotional centers in areas such as the hypothalamus and cingulate adding tone. The left hemisphere dominates speech, while the right is more balanced for singing and music. All vocal learners use learned sounds emotionally; only a few, including humans, some parrots and dolphins, use them semantically.

10. Reading and writing run through silent speech
When you read, visual signals travel to Broca's area and you silently speak the words, with tiny electrical signals reaching the vocal muscles. Writing works the same way, so speech bridges thought and the written word. Writing flows best when your hand or typing keeps pace with your inner speech.

EXAMPLES

1. The caninch and the Bengalese finch
A zebra finch raised with a canary at Rockefeller sang a hybrid song. A young zebra finch placed between its own species and a Bengalese finch learned its own species' song, but learned the Bengalese song well if its own species was removed. Peter Marler called this the innate predisposition to learn, akin to linguists' universal grammar.

2. Stuttering birds and the basal ganglia
Damage to the striatal part of the songbird speech pathway caused stuttering as the region recovered, driven by new

neurons not yet integrated properly. Birds recovered in three to four months thanks to neurogenesis mammals lack. In humans, basal ganglia disruption is also implicated in both acquired and developmental stuttering.

3. Snowball the cockatoo

The cockatoo famous for dancing to music, with many imitators online, illustrates the 2009 finding that vocal learners can entrain to a beat; Jarvis says Snowball out-dances some scientists in one video.

4. Jarvis's path from ballet to birdsong

From a family of singers, he won dance contests as a teen, trained at the High School of Performing Arts, Alvin Ailey and Joffrey schools, and was invited to audition for the Alvin Ailey company. He chose science instead, studying birdsong with Fernando Nottebohm at Rockefeller, and still dances, which he believes keeps his brain sharp.

5. Sequencing all vertebrates

Jarvis leads the Vertebrate Genomes Project, aiming to sequence all 70,000 vertebrate species, within the Earth BioGenome Project's goal of all 2 million eukaryotes. Older genomes contained errors such as false gene duplications. Skin and fur color show convergence: darker pigmentation near the equator repeatedly evolved through the same melanin-related genes.

OTHER RELEVANT

1. Keep moving to stay cognitively sharp

Because speech circuits sit beside motor circuits, Jarvis argues consistent movement, such as dancing, walking or running, plus practicing speaking or singing, helps keep cognitive circuits in tune into old age. He offers this from personal experience, not a trial; Huberman reports long slow runs help him prepare for long solo episodes.

2. Treat stuttering with sensorimotor tools

Speaking more slowly and tapping out a rhythm, approaches that tie what you hear to what you produce, help many adults reduce stuttering. Stuttering does not indicate slow thinking.

3. Match writing speed to thought

Huberman writes by hand with a Pilot V5 or V7 pen because it lets his writing rate match his thinking. Karl Deisseroth's practice is to sit still and think in complete sentences. Silently singing lyrics warms up speech circuits before talking.

4. Mind the speed of short-form text

Jarvis does not think texting erodes language ability; it repurposes it. But short messages are easy to over- or under-interpret, and fast writing can expose unfiltered meaning. He half-jokingly suggests technology buffers that would tell you to slow down before sending a bad thought.

Time Perception & Entrainment by Dopamine, Serotonin & Hormones

Date: 2021-11-15 · Duration: 1:14:17
URL: https://www.youtube.com/watch?v=8IWDAqodDas

KEYPOINTS

1. Circannual rhythms run on melatonin, which tracks day length
Light hitting the eyes suppresses melatonin; flipping on a bright bathroom light at night can drop it close to zero. Because the brain averages light exposure across days, long spring days mean progressively less melatonin and short winter days progressively more. Melatonin also regulates testosterone and estrogen, which is why most (not all) people feel more energy in spring and lower mood and energy in winter.

2. Skin acts as a hormone-influencing organ that responds to sunlight
Huberman cites Parikh et al. in Cell Reports: across the year, people made more testosterone and estrogen in longer days, correlating with romantic desire, combativeness and overall mood. About 2 hours a day of sunlight on exposed arms, upper back, neck and face drove significant increases, even with cloud cover, and sunscreen did not appear to block it. He notes skin health and cancer risk still take priority.

3. Every cell carries a 24-hour gene–protein timer
Clock genes such as Per, Bmal and Clock are expressed, make a protein that shuts the gene off, and restart once the protein is used up, a loop that takes about 24 hours. Morning light, evening light and darkness at night keep these cellular clocks locked to the outside world. Huberman stresses that poor circadian entrainment is linked to higher cancer and obesity risk, mental health problems, slower wound healing, worse performance and hormone disruption.

4. Losing circadian cues degrades time perception at every scale
In Aschoff's classic 1985 isolation experiments, repeated many times since, people kept without clocks, windows or regular light underestimated their stay: after about 42 days they guessed 28 or 36. Their ability to count off short intervals such as 2 minutes, normally accurate within 5–15 seconds, also fell apart, and Huberman links accurate interval timing to task performance.

5. Focus comes in roughly 90-minute ultradian blocks that you can start whenever you choose
Nathaniel Kleitman's basic rest–activity cycle governs sleep and also waking focus. Sleep cycles are hardwired, but a waking work cycle starts when you decide it does. Regardless of who you are, focus drops off around 100–120 minutes, because acetylcholine, dopamine and norepinephrine release can't be sustained. Huberman says you shouldn't expect to drop into deep focus immediately.

6. Time perception comes in three modes
Present-moment perception works like an interval timer, either fine-slicing time or ticking slowly. Prospective timing is a stopwatch running forward, where you have to decide how many tick marks to set for, say, 5 minutes. Retrospective timing reconstructs the past from memory, such as working out the gap between lunch and dinner last week. Each mode is shaped by neuromodulators.

7. Dopamine and norepinephrine raise your perceptual 'frame rate', so you overestimate elapsed time
When drugs raise dopamine, people asked to mark one minute call it at around 38 seconds. Huberman compares this to filming at 4,000 instead of 30 frames per second: more frames make events look slower. Norepinephrine, which is made from dopamine, has a similar effect.

8. Serotonin lowers the frame rate, so you underestimate elapsed time
In human studies using serotonin-raising drugs and cannabis, people asked to mark 5 minutes let about 6 pass. Huberman says the evidence suggests dopamine and norepinephrine dominate the first half of the waking day and serotonin rises toward evening, with early evidence that people overestimate time passing in the morning and underestimate it later.

9. Trauma can 'overclock' memory
Extreme arousal pushes dopamine and norepinephrine so high that events are experienced in ultra-slow motion. The hippocampus stores both which neurons fired and the rate at which they fired, so these memories are stamped in at high resolution and are hard to shake. Huberman says treatments such as EMDR, exposure therapy, CBT and newer ketamine approaches partly work by giving the person control over how fast the memory plays back, which helps separate the emotional weight from the memory.

10. Dopamine release marks the boundaries of your experienced time bins
Dopamine signals both expected rewards and surprises, positive or negative. Huberman argues that how often dopamine is released sets how you carve up the day into segments, which turns habits into time markers as well as sources of motivation.

EXAMPLES

1. Basketball-viewing fMRI study (Anthony et al., 2020, Neuron)
People watching recorded games showed dopamine-related activity in the nucleus accumbens and VTA when their predictions came true and when they were surprised. How often these signals fired predicted how viewers divided the game's time into segments, more than the game clock or the action did.

2. Blinking resets time (Terhune et al., Current Biology)
The paper 'Time dilates after spontaneous blinking' showed each blink shifts time perception toward overestimation. Arousal and dopamine increase spontaneous blink rate, so blinking works like a camera shutter. Huberman suggests blinking less to slow perceived time and more to speed it up, while admitting you miss information when you blink.

3. Cold water and the long three minutes

Huberman cites a European Journal of Physiology study reporting that cold exposure raises baseline dopamine about 2.5-fold, a long-lasting increase that doesn't appear addictive. That dopamine rise is why three minutes in an ice bath feels endless: the discomfort is being recorded at higher resolution.

4. Amusement-park day vs dentist waiting room

A fun, varied, dopamine-rich day flies by in the moment but is remembered as long and full, as with a vacation recalled 6–8 months later. A boring dentist wait drags in the moment but shrinks to almost nothing in memory.

5. Three apartments in New York

In Huberman's thought experiment, a year in one apartment with 100 new experiences feels like a year. Living in three places with three times the novelty would feel much longer. The same applies to people: sharing several new settings with someone makes you feel you've known them longer, even if the total time is identical.

OTHER RELEVANT

1. Anchor your circadian clock with light, exercise and meal timing

View 10–30 minutes of bright light, ideally sunlight, within an hour of waking and again in the late afternoon or evening. Avoid sunglasses if it's safe to do so (glasses and contacts are fine) and minimize bright light of any color at night. Exercise at a roughly consistent time, within about ±2 hours day to day, and keep meals within a consistent window. The exact meal times matter less than the window.

2. Cap deep-work blocks at about 90 minutes and space them out

Remove distractions (phone away, sometimes internet off) and set a start time. Huberman recommends one or two blocks a day, three at most, separated by 2–4 hours, and says most people can't handle more than two. Email and messaging don't count as deep work.

3. Match the task to the time of day

Do precise, rule-bound work with right and wrong answers (math, accounting, musical scales, recipes, skill execution) earlier in the day, when you're a 'higher-resolution camera'. Save brainstorming and creative blending for the more serotonergic afternoon. Huberman calls this a broad-strokes framework, and notes that poor sleep blurs these daily phases.

4. Use habits as markers that divide your day

Place reliable, rewarding habits at set points, for example 8 a.m. and 10 a.m., so their dopamine release marks the start of distinct stretches of the day. In the cold, you can distract yourself from the slow-motion discomfort with a song, counting or a metronome ticking every 10 seconds. For further reading he recommends Dean Buonomano's 'Your Brain Is a Time Machine'.

The Science of Hearing, Balance & Accelerated Learning

Date: 2021-07-05 · Duration: 2:03:36
URL: https://www.youtube.com/watch?v=JVRyzYB9JSY

KEYPOINTS

1. Short rests during practice speed up skill learning
A Cell Reports study from a lab led by a neuroscientist named Cohen (Huberman jokes, not the musician Leonard Cohen) had people practise a piano-key sequence (G-D-F-E-G) either continuously or in 10-second bursts separated by 10 seconds of doing nothing. Learning and retention were much faster with the breaks. Brain imaging showed the hippocampus and cortex replaying the sequence about 20 times faster during rest, which the authors call 'micro-offline gains.' It builds on the spacing effect Ebbinghaus first described in 1885.

2. The cochlea sorts sound by frequency like a prism
The pinna's shape amplifies high frequencies. Sound vibrates the eardrum and the three small bones (malleus, incus, stapes), which press on the fluid-filled cochlea. One end of the cochlea responds to high pitches and the other to low, much like piano keys. The auditory cortex keeps that order in 'tonotopic maps.' Hair cells lost to damage can't currently be replaced, though groups including some at Stanford are working on it.

3. Binaural beats change brain state, but they aren't learning magic
Huberman says the independent, non-sponsored research is surprisingly solid. Delta frequencies (1–4 Hz) help with falling and staying asleep, theta (4–8 Hz) brings on a meditative state, and higher frequencies, up to gamma (32–100 Hz), support alertness, focus and problem-solving. The strongest benefits are for reducing anxiety, including at the dentist, and reducing chronic pain (three good-quality studies). Effects on cognition, working memory and creativity are modest. Their value is simply in shifting your state.

4. Low-level white noise improves learning in adults, possibly through dopamine
An fMRI study found that low-intensity white noise improved auditory working memory, and a 54-subject study found that background noise helped as long as it wasn't too loud. A 2014 Journal of Cognitive Neuroscience paper showed white noise increasing activity in dopamine-rich midbrain areas (substantia nigra/VTA) and the right superior temporal sulcus. The idea is to raise baseline dopamine slightly, not to give yourself a 'favourite song' rush.

5. White noise may harm auditory development in infants
Work by Mike Merzenich and his student, done in young animals, found that constant white noise disrupted tonotopic maps in the auditory cortex. White noise carries no structured frequency information, unlike a voice. Huberman flags this as a reason to be cautious about running white-noise machines all night for babies, while noting the evidence comes from animals.

6. Focused listening can rewire the adult auditory cortex
Gregg Recanzone and Merzenich showed that passive listening changed little, but telling subjects to attend to specific frequencies or cues sped up learning and remapped the cortex in adults. This was some of the first evidence that adult brains can change. In practice, it means picking out particular words, keys or scales to concentrate on during each practice session.

7. Balance depends on the inner ear, vision and the cerebellum working together
The three semicircular canals detect head rotation, and the cerebellum combines that with visual and body-position information. Vision and balance drive each other, which is why standing on one leg with your eyes closed causes so much postural sway. Huberman notes that the cerebellum's non-motor outputs connect to serotonin and dopamine systems, which may partly explain why balance-heavy activities feel good.

8. Leaning while accelerating trains the vestibular system best
The vestibular system responds to acceleration and head tilt, not just position. Moving forward while tilted relative to gravity, as in carving on a skateboard, surfboard or snowboard or leaning a bike into a turn, challenges it in a way that staying upright, or even balancing on a gym ball, doesn't.

EXAMPLES

1. Tinnitus supplements with some evidence
Huberman found four supplements studied without obvious commercial bias. Melatonin, about 3 mg a day for 30 days to 6 months, produced modest but significant reductions across four studies of 30 to 100+ participants. Ginkgo biloba had 'limited evidence,' mostly for age-related tinnitus (one study with 978 people). Zinc at 50 mg elemental was tested in one double-blind study of 41 people. Magnesium at 532 mg elemental was tested in a single phase 2 trial of 19 people. He's not personally a fan of melatonin for sleep and says to talk to your doctor.

2. The ear-size age formula
Ears keep growing throughout life, faster in later years, partly because of changes in collagen. Huberman describes a published formula: measure each ear's outer circumference in millimetres, average the two, subtract 88.1 and multiply by 1.96 to estimate biological age.

3. Salt and lightheadedness
Huberman distinguishes dizziness (the world spinning) from lightheadedness (feeling like you'll fall). Family members who believed they had blood-sugar problems, with shakiness, lightheadedness and nausea, were helped by adding a little sea salt to their water. He says this won't fix every case.

4. Bats and the Doppler effect
Bats emit sounds and read how quickly the echoes return, and how the timing changes, to tell whether they're approaching an object. They build an acoustic picture of trees, buildings and people.

OTHER RELEVANT

1. Add 10-second pauses when you practise

While practising a skill, alternate short bouts of reps with 10 seconds of doing nothing: no phone, eyes closed if you like. Afterward, add a 20-minute nap or quiet rest. Huberman suggests the two may work together, though that combination hasn't been tested.

2. Keep background noise low

If you study with white noise, keep it audible but unobtrusive, roughly the lower third of the volume dial, and even quieter through headphones, which make sound feel as if it's inside your head. If your attention can 'disappear into the work,' the volume is about right. Avoid two-hit exposures, like loud headphones followed by a concert, which damage hair cells.

3. A few minutes of balance training

Stand on one leg and shift your gaze from about two feet away, out to the farthest point you can see, then back in. Or keep your gaze fixed while changing posture. Two to ten minutes a few times a week is enough, and single-leg or asymmetric positions work best.

4. For motion sickness, look ahead but don't fix your gaze

Get up on deck or look out the front windshield, but let your eyes move with the motion instead of locking onto one point on the horizon. Phones, seat-back screens and dividers separate what you see from what your inner ear feels. Driving helps because you also get feedback from your own body.

How Your Brain Works & Changes

Date: 2021-01-04 · Duration: 1:02:31
URL: https://www.youtube.com/watch?v=H-XfCl-HpRM

KEYPOINTS

1. Think 'nervous system,' not just 'brain'
Huberman describes the brain, spinal cord and the two-way connections to every organ as one continuous loop, like a Möbius strip with no clear start or end. The nervous system governs other systems and is shaped by them. For example, it signals the spleen to release killer cells during infection, and the 'ache' in a stomach ache is a nervous-system event.

2. Experience is electrical patterns across neurons and synapses
Ramón y Cajal and Camillo Golgi's staining work around 1900 showed the nervous system is made of separate nerve cells separated by gaps (synapses), not one giant cell. Neurons release chemicals into synapses, and the next cell converts them into electrical signals. Huberman compares memories to songs played as patterns of piano keys. The hippocampus doesn't store sentences but patterns of activity, and déjà vu is the same pattern firing again, like a familiar song played on a different instrument.

3. The brain is a map of experience, with cells this specific
An early-2000s paper in Nature found a single neuron in a healthy person that fired only when they viewed Jennifer Aniston. If you can recognize her face, Huberman says, you have 'Jennifer Aniston neurons.' He uses this to show that we come into the world biased to learn certain things, and experience then fills in the map.

4. Sensation is fixed, but perception is steered by attention
Huberman lists five or six things the nervous system does: sensation, perception, emotions, thoughts, actions and plasticity. Sensory receptors set non-negotiable limits. Other animals detect what we can't, such as heat emissions or magnetic fields used for long-distance migration, and he urges skepticism toward people claiming robust human magnetic sensing. Perception is whichever sensations you attend to. Your feet were touching the floor all along, but you notice it only when you direct attention there.

5. You have two attentional spotlights, so a form of multitasking is real
Primates, including humans, are capable of covert attention. You can place one spotlight on what you're reading or listening to and a second on how your food tastes or where your child is. Huberman pushes back on the blanket claim that multitasking is impossible.

6. Neuromodulators bias whole circuits, which is why antidepressants have side effects
Dopamine, serotonin, acetylcholine and epinephrine make some circuits more likely to be active and others less. Huberman frames serotonin as feeling good about what you already have, and dopamine as less about reward and more about motivation toward things out in the world. Drugs developed from the 1950s–70s altered several systems at once. Serotonin-raising antidepressants can lift mood but, at too high a dose or for the wrong person, can dull motivation, appetite or libido because serotonin acts on receptors in those circuits too.

7. Deliberate action means top-down control over reflex, and it feels like strain
Walking runs on brainstem central pattern generators. Hiking over rocks requires forebrain top-down control. Huberman calls deliberate mode 'DPO,' for analyzing Duration, Path and Outcome. Suppressing a reflexive response releases norepinephrine (adrenaline), which feels like agitation. Children lack the forebrain circuitry for full top-down control until around 22–25, which is why they rock, fidget and grab candy, and frontal-lobe damage can produce blurting and impulsivity.

8. Neuroplasticity is a two-phase process: focused effort, then rest
Until about age 25 the brain changes fairly passively. After that, change has to be self-directed. In waking, epinephrine from the brainstem creates alertness, and acetylcholine acts as a 'highlighter' that marks which neurons were active (dopamine and serotonin also gate plasticity). The actual rewiring happens later, during sleep and non-sleep deep rest. Agitation and strain while learning are signs the process has been triggered, not that it's failing.

9. Your days, as well as your nights, run in ~90-minute ultradian cycles
Sleep cycles through stages one to four in roughly 90-minute blocks, and similar cycles continue while you're awake, governing how well you can focus. The autonomic nervous system acts as a seesaw between alertness and calm, and it governs both these cycles and the daily wake–sleep arc. To direct plasticity, you need to master both transitions, waking up and falling asleep. Huberman says sleep timing gets too little discussion and that fragmented schedules like the 'Uberman' are unlikely to match a solid block of sleep.

EXAMPLES

1. World War I bullet wounds mapped the brain
Changes in ammunition meant bullets made small, discrete entry and exit holes, and better wound cleaning meant more soldiers survived. Neurologists collected patients with specific deficits. Some could see a face but not tell whose it was, and others spoke gibberish yet understood language perfectly. This showed that speech production and comprehension rely on separate regions.

2. Blind braille readers
People born blind use the brain area normally devoted to vision for reading braille, which Huberman cites as an extreme example of experience-driven plasticity.

3. 20 minutes of deep rest after hard learning
A study Huberman cites (not from his lab) found that taking about 20 minutes immediately after an intense learning bout to

deliberately switch off focused thinking accelerated plasticity.

4. A tone during deep sleep boosts learning

In another study, people learned a language or motor skill while a tone played periodically. Replaying that tone during deep sleep, without any need for dreaming, led to faster learning and better retention. The tone works like a Pavlovian reminder to the sleeping brain about what mattered that day.

OTHER RELEVANT

1. Embrace the strain when learning

If learning a skill or holding back a reaction feels agitating, that's epinephrine and the attention it creates, which is the gateway to change. Push through focused bouts instead of reading the discomfort as failure.

2. Follow focus with deliberate rest

After a hard learning session, take a period of non-sleep deep rest where your mind can drift, and protect your sleep. That's when the changes are consolidated.

3. Work with 90-minute blocks and notice your best time of day

Plan your deepest learning inside roughly 90-minute cycles, and note whether you learn better early in the day or later. Some people are strong morning learners and weak in the afternoon. Experiment with yourself, and run new tools past a healthcare professional.