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The Top Ten Brain Science And Psychology Studies Of 2013

fMRI scanner at a neuroscience lab (Photo credit: Wikipedia)

Putting it mildly, 2013 was an eventful year for brain science. This Top 10 list isn't meant to be exhaustive (given how many studies are published each year, it never could be), but it's a sturdy sampling of incredible work being conducted around the world, moving us closer to solving some extremely vexing puzzles about brains and behavior.

1. How the Brain Takes Out Its Trash While We Sleep

In 2013, layers were peeled back from two interrelated mysteries: the function of sleep, and how the brain removes its waste byproducts.

While it's been known for some time that the brain doesn't directly use the body's lymphatic system (our body-wide filtering and waste removal system) to dump its toxic waste, the mechanism that it does use wasn't identified until 2012. The research team that made this discovery was led by University of Rochester neurosurgeon, Maiken Nedergaard, who dubbed the brain's waste-removal mechanism the "glymphatic system."

The glymphatic system relies on cerebrospinal fluid (CSF) to flush out neurotoxins via pathways separate from the lymphatic system. Among the toxins that are flushed is beta amyloid, a protein that's found in clumps in the brains of Alzheimer's sufferers.

In 2013, Nedergaard's research team followed up on this discovery by identifying "hidden caves" that open in the brain while we sleep, allowing cerebrospinal fluid to flush out neurotoxins through the spinal column.

The implications of this research can't be overstated: failing to get enough sleep isn't just a bad idea for all of the reasons we already know, but over time it could also lead to neurological disorders like Alzheimer's. If the study's findings are accurate, our brains need sleep to remove waste byproducts like beta amyloid that eventually become brain killers.

The study was published in the journal, *Science*.

2. To Your Brain, Me is We

A 2013 study from University of Virginia researchers supports a finding that's been gaining science-fueled momentum in recent years: the human brain is wired to connect with others so strongly that it experiences what they experience as if it's happening to us.

The researchers had participants undergo fMRI brain scans while threatening to give them electrical shocks, or to give shocks to a stranger or a friend. Results showed that regions of the brain responsible for threat response – the anterior insula, putamen and supramarginal gyrus – became active under threat of shock to the self; that much was expected.

When researchers threatened to shock a stranger, those same brain regions showed virtually no activity. But when they threatened to shock a friend, the brain regions showed activity nearly identical to that displayed when the participant was threatened.

"The correlation between self and friend was remarkably similar," said James Coan, a psychology professor in U.Va.'s College of Arts & Sciences who co-authored the study. "The finding shows the brain's remarkable capacity to model

self to others; that people close to us become a part of ourselves, and that is not just metaphor or poetry, it's very real."

The study was published in the journal, *Social Cognitive and Affective Neuroscience.*

3. Your Brain Sees Even When You Don't

A 2013 study published in *The Journal of Neuroscience* suggests that the brain can "see" someone else's actions even when the ability to visually see has been destroyed.

Cortical blindness refers to the loss of vision that occurs when the primary visual cortex no longer functions, generally as the result of injury. There's no longer an ability to visually perceive the world in the sense with which we're most familiar (even though the eyes still technically work), but that doesn't necessarily mean the brain no longer sees.

In this study a patient with full cortical blindness could still react to another person's gaze. While in an fMRI machine, the patient was exposed to gazes directed at him and gazes directed away from him. On the face of it, neither should matter — his visual cortex couldn't perceive any sort of gaze. But the brain scan indicated that another part of his brain definitely could.

The patient's amygdala, the brain area associated with figuring out whether external stimuli is a threat, showed a distinctly different activation pattern when the gaze was directed at the patient than when directed away from him.

In other words, it didn't matter that his visual cortex couldn't catch the gaze—another part of his brain did regardless, and that's quite incredible.

4. Yes, Stress Really Does Feed Cancer

For years we've heard that there's a mind-body connection between stress and cancer. The claim is anecdotal, but has a certain horse sense that appeals to reason – stress is hard on the body, causing hormonal reactions that can potentially influence the development of cancerous cells.

A 2013 study didn't quite prove the claim, but did indicate that once cancer has taken hold, stress biochemically feeds its growth. The study, by researchers at Wake Forest Baptist Medical Center, focused on the effects of stress on prostate cancer, and found that stress can both reduce the effectiveness of prostate cancer drugs and accelerate the development of the cancer.

The study team, headed by George Kulik, D.V.M., Ph.D., associate professor of cancer biology, tested the effects of behavioral stress in two different mouse models of prostate cancer.

One model used mice that were implanted with human prostate cancer cells and treated with a drug that is currently in clinical trial for prostate cancer treatment. When the mice were kept calm and free of stress, the drug destroyed prostate cancer cells and inhibited tumor growth. However, when the mice were stressed, the cancer cells didn't die and the drug did not inhibit tumor growth.

In the second model, mice genetically modified to develop prostate cancer were used. When these mice were repeatedly stressed, the size of prostate tumors increased. When the mice were treated with bicalutamide, a drug currently used to treat prostate cancer, their prostate tumors decreased in size. However, if mice were subjected to repeated stress, the prostate tumors didn't respond as well to the drug.

After analyzing the data, researchers identified the cell signaling pathway by which epinephrine, a hormone also known as adrenaline–triggered at high levels during times of stress–sets off the cellular chain reaction that controls cell death.

"Considering that prostate cancer diagnosis increases stress and anxiety levels, stress-induced activation of the signaling pathway that turns off the cell death process may lead to a vicious cycle of stress and cancer progression," Kulik said.

The findings were published in the *Journal of Clinical Investigation*.

5. Move Over Extroverts and Introverts, Here Come the Ambiverts

In the psychology of personality category, a 2013 study overturned yet another personality stereotype that's gone virtually unquestioned for decades: that extroverts are inherently better sellers than everyone else.

The study, published in the journal *Psychological Science*, indicates that not only is that stereotype wrong, but there's an entirely different personality type that stands well above the others in sales prowess.

The study was conducted by researcher Adam Grant of The Wharton School of the University of Pennsylvania, also author of the book *Give and Take: A Revolutionary Approach to Success*. Grant predicted that extroverts, contrary to popular lore, would not bury other personality types when it came to closing sales — but rather, ambiverts, people who are more or less equal parts extroverted and introverted, would perform best.

Grant conducted a personality survey and collected three-months of sales records for more than 300 salespeople, both men and women. As he predicted, people whose scores put them in between extreme extroversion and introversion turned out to be the best salespeople. In a three-month period, they made 24% more in sales revenue than introverts, and 32% more in revenue than extroverts.

Perhaps even more surprising, Grant found that the two extreme personality types pulled in roughly the same percentage of sales. Being highly extroverted wasn't even a plus when compared against the personality type we generally think of as the worst candidate for high-performance sales.

Because ambiverts embody traits from both sides of the personality spectrum—in a sense, they have a built in 'governor' that regulates their exuberance–they don't trip over the obstacles that handicap their more extroverted counterparts.

"The ambivert advantage stems from the tendency to be assertive and enthusiastic enough to persuade and close, but at the same time, listening carefully to customers and avoiding the appearance of being overly confident or excited," Grant said.

6. Mini Brains Created With Stem Cells

This past year also saw some groundbreaking news in the stem-cell category of neuroscience: for the first time, scientists grew miniature human brains from stem cells, reported Reuters Health. The implications of this development are massive, not the least of which is eventually understanding the inner workings of severe neurological disorders and how to defeat them.

The researchers started with human stem cells—the often-controversial, undifferentiated (or "blank") human cells that are capable of giving rise to a host of differentiated cells—and cultured them into "cerebral organoids" (more simply, "mini brains"). Stem cells have been used to grow a variety of organ tissue—including a liver and a trachea—but never before has brain tissue with multiple, distinct parts been created in a lab.

According to the Reuters report, Juergen Knoblish and Madeline Lancaster at Austria's Institute of Molecular Biotechnology and fellow researchers at Britain's Edinburgh University of Human Genetics cultured the stem cells with a cocktail of nutrients, and grew tissue called neuroectoderm – a layer of cells in the embryo from which all parts of the brain and nervous system develop.

This tissue was then placed into a spinning bioreactor that circulates oxygen and nutrients, catalyzing the eventual growth of cerebral organoids. After one month, the tissue had organized itself into basic developing brain regions, including the retina and cerebral cortex. At two months, the tiny organoids—about 4 millimeters long—contained firing neurons and identifiably different types of neural tissue. The scientists had created tiny, primitive human brains.

To demonstrate the usefulness of their discovery, the researchers used the organoids to model the development of a rare neurological condition called microcephaly—in which patients develop an abnormally small head. By modeling the condition in a lab, researchers can reverse engineer it and find out why it develops.

The research team acknowledged that they had not created a full-scale, fully functioning human brain, and that doing so is a long way off, but they said they had accomplished their initial goal —to "analyze the development of human brain tissue and generate a model system…to transfer knowledge from animal models to a human setting."

Source: Scientists Grow "Mini Human Brains" From Stem Cells; Reuters.

7. How Exercise Makes Your Brain Grow

Research into "neurogenesis"—the ability of certain brain areas to grow new brain cells—took an exciting turn in 2013. A study published in the journal *Cell Metabolism* suggests that not only can we foster new brain cell growth through exercise, but it may eventually be possible to "bottle" that benefit in prescription medication.

The hippocampus, a brain area closely linked to learning and memory, is especially receptive to new neuron growth in response to endurance exercise. Exactly how and why this happens wasn't well understood until recently. Research has discovered that exercise stimulates the production of a protein called FNDC5 that is released into the bloodstream while we're breaking a sweat. Over time, FNDC5 stimulates the production of another protein in the brain called Brain Derived Neurotrophic Factor (BDNF), which in turns stimulates the growth of new nerves and synapses – the connection points between nerves – and also preserves the survival of existing brain cells.

What this boils down to in practice is that regular endurance exercise, like jogging, strengthens and grows your brain. In particular, your memory and ability to learn get a boost from hitting the pavement. Along with the other well-established benefits of endurance exercise, such as improved heart health, this is a pretty good reason to get moving. If jogging isn't your thing, there's a multitude of other ways to trigger the endurance effect – even brisk walking on a regular basis yields brain benefits.

Researchers from the Dana-Farber Cancer Institute at Harvard Medical School (HMS) have also discovered that it may be possible to capture these benefits in a pill. The same protein that

stimulates brain growth via exercise could potentially be bottled and given to patients experiencing cognitive decline, including those in the beginning stages of Alzheimer's and Parkinson's.

"What is exciting is that a natural substance can be given in the bloodstream that can mimic some of the effects of endurance exercise on the brain," said Bruce Spiegelman, PhD, of Dana-Farber and HMS and co-senior author of the research report with Michael E. Greenberg, PhD, chair of neurobiology at HMS.

8. Electrical Stimulation Helps the Brain Put On the Brakes

In the "exciting but frightening" category, research published in the *The Journal of Neuroscience* showed that harmless electrical stimulation can boost self-control by amplifying the human brain's "brakes."

Researchers from The University of Texas Health Science Center at Houston (UTHealth) and the University of California, San Diego asked study participants to perform simple tasks in which they had to exert self-control to slow down their behavior. While doing so, the team used brain imaging to identify the areas of the participants' prefrontal cortex (sometimes called the brain's "command and control center") associated with the behavior—allowing them to pinpoint the specific brain area that would need a boost to make each participant's "braking" ability more effective.

They then placed electrodes on the surface of the participants' brains associated with the prefrontal cortex areas linked with the behavior. With an imperceptible, computer-controlled electrical charge, researchers were able to enhance self-control at the exact time the participants needed it.

"There is a circuit in the brain for inhibiting or braking responses," said Nitin Tandon, M.D., the study's senior author and associate professor in The Vivian L. Smith Department of Neurosurgery at the UTHealth Medical School. "We believe we are the first to show that we can enhance this braking system with brain stimulation."

Though this research conjures a few frightening visions, you can relax knowing that we're a long way from externally controlling peoples' behavior. The true value of this study is to demonstrate that the brain's self-control circuit can be amplified, at least under certain conditions–and eventually that could be good news for sufferers of behavioral disorders like OCD and Tourette Syndrome.

9. Tool That Seeks Consciousness in the Brain

An experimental tool designed in 2013 to "peek" into a patient's brain and find signs of consciousness could eventually give doctors a way to more accurately judge chances of recovery from serious brain trauma – and in the process change the nature of end-of-life decisions.

Until now, doctors don't have many methods available to gauge the consciousness of a patient unable to respond verbally or in other subtle ways in response to simple questions–such as blinking an eye, squeezing a hand, or raising a finger. In these cases, typically when a patient has suffered a severe brain injury, there's ample guesswork that goes into determining whether consciousness is still lingering under the surface.

The best clinical method available to get closer to an answer involves placing the patient in an MRI machine and scanning the brain while telling the patient to envision an action like throwing a ball or running through a field. By tracking activity patterns in the patient's brain, it's theoretically possible to tell if the person is able to unconsciously acknowledge and process the request. If it appears that the patient's brain can respond even though the patient can't verbalize the response, the person is said to suffer from "locked-in syndrome".

The problem with this method is that it's far from clear what the brain activity is actually revealing about consciousness. Significant brain activity is possible even in a vegetative state, and isn't necessarily a clue that recovery is possible.

Since consciousness is spread across multiple brain regions, it's possible for one part of the brain to respond while others are entirely unresponsive. One way to think about this is the starter on a damaged car engine still working even though gas can't reach the engine; a

minimal "signal" from the starter is produced by turning the key, even though the engine can't run.

The new tool, developed by researchers from Italy's University of Milan, could provide doctors with a more objective method that gauges the complexity of a patient's consciousness. The tool combines three steps: first a magnetic pulse is sent through a coil into the brain designed to "wake it up," and then an EEG machine measures brain wave activity produced by neurons firing in response to the pulse. Finally, the activity is measured via a formula that puts a finer point on the nature of the patient's consciousness.

That final step is the secret ingredient that makes this tool different: instead of simply trying to identify brain activity (something MRI machines can already do) it produces a measure of the *complexity* of consciousness–what the researchers call the perturbational complexity index (PCI). "Consciousness can grow and shrink," said Dr. Marcello Massimini, a neurophysiologist who led the research, in an AP report about the experimental tool. By figuring out the level of "growing" or "shrinking", doctors can more objectively gauge whether a patient is exhibiting an adequate level of consciousness to recover.

The researchers emphasized that the tool is far from becoming a bedside medical option, but the research opens the door to measuring levels of consciousness that correlate with recovery from serious brain injury. This knowledge could potentially change the way end-of-life decisions are made by providing doctors and loved ones with a firmer means to evaluate whether a patient has the capacity to recover.

The study was published in the journal, *Science Translational Medicine*.

10. The Antidepressant Sweet Spot for Coffee Drinkers

Coffee research is a crap shoot at best – every year new studies come out suggesting benefits and drawbacks of our favorite morning companion. But in 2013, researchers from the Harvard School of Public Health made an especially significant contribution to coffee

research that found a correlation between drinking 2-4 cups of caffeinated coffee each day and lower suicide risk among adults.

The study, published in *The World Journal of Biological Psychiatry*, was a meta-review of three extensive U.S. health studies that included a total of 43,599 men and 164,825 women. Consumption of caffeine (from tea, soda and chocolate), coffee and decaffeinated coffee was evaluated among study participants every four years via questionnaire. Across all three studies, coffee accounted for the majority of caffeine consumed at 71% of the total.

Causes of death were tracked during the study period by reviewing death certificates; 277 deaths were the result of suicide.

The analysis showed that the risk of suicide among adults drinking 2-4 cups of coffee (the equivalent of about 400 mg of caffeine) a day was 50% less than the risk for adults who drank decaffeinated coffee or one cup or less of caffeinated coffee. Drinking more than 4 cups of coffee wasn't associated with lower suicide risk.

The neurochemistry behind the finding makes sense. As discussed in a previous article, caffeine acts as an expert mimic of a chemical called adenosine in the brain and other parts of the body. Adenosine is a sort of checks-and-balances chemical produced by neurons as they fire throughout the day; the more adenosine is produced, the more the nervous system ratchets down activity, until we eventually fall asleep and reboot the process.

By mimicking adenosine, caffeine blocks receptors in the nervous system from receiving the signals to decrease energy expenditure. When that happens, levels of the brain's homegrown neuro-stimulants—dopamine and glutamate—increase, and we experience the brain stimulating effects associated with drinking a big cup of java. Those effects may be a potent counterbalance to depression for a segment of the coffee-drinking population.

Have more studies you'd like to add to this list or comments on any of those above? Please put them in the comments section for all to see. Thanks!

You can find David DiSalvo on Twitter @neuronarrative and at his website, The Daily Brain. His latest book is *Brain Changer: How Harnessing Your Brain's Power To Adapt Can Change Your Life*.

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