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News & Events

News

News

Media Coverage

Videos

Events

Upcoming Events

Past Events

Event Series



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Save the date: Join us for our fifth annual symposium on Oct. 11 to hear experts discuss artificial and natural intelligence, machine learning, and more. stanford.io/2lwj8R8



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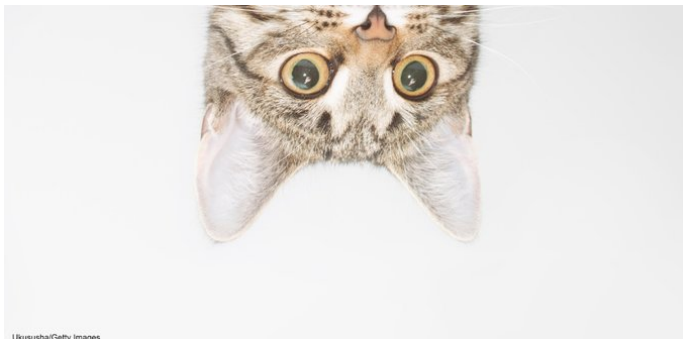
Can precision medicine help match individuals with the most effective treatment for their depression? Leanne Williams believe part of the solution starts with collecting more data about patients with depression. stanford.io/2ljzw7D

May 16, 2018



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"It's important that we not have completely predictable behavior. You need to have a little unpredictability to survive," Bill Newsome noted. "Randomness in the nervous system is really important because it allows you explore more parts of the space."



Ukususha/Getty Images

Why the modern world is bad for your brain

Mar 11 2015 | The Guardian

By Daniel J. Levitin

Our brains are busier than ever before. We're assaulted with facts, pseudo facts, jibber-jabber, and rumour, all posing as information. Trying to figure out what you need to know and what you can ignore is exhausting. At the same time, we are all doing more. Thirty years ago, travel agents made our airline and rail reservations, salespeople helped us find what we were looking for in shops, and professional typists or secretaries helped busy people with their correspondence. Now we do most of those things ourselves. We are doing the jobs of 10 different people while still trying to keep up with our lives, our children and parents, our friends, our careers, our hobbies, and our favourite TV shows.

Our smartphones have become Swiss army knife-like appliances that include a dictionary, calculator, web browser, email, Game Boy, appointment calendar, voice recorder, guitar tuner, weather forecaster, GPS, texter, tweeter, Facebook updater, and flashlight. They're more powerful and do more things than the most advanced computer at IBM corporate headquarters 30 years ago. And we use them all the time, part

of a 21st-century mania for cramming everything we do into every single spare moment of downtime. We text while we're walking across the street, catch up on email while standing in a queue – and while having lunch with friends, we surreptitiously check to see what our other friends are doing. At the kitchen counter, cosy and secure in our domicile, we write our shopping lists on smartphones while we are listening to that wonderfully informative podcast on urban beekeeping.

But there's a fly in the ointment. Although we think we're doing several things at once, multitasking, this is a powerful and diabolical illusion. Earl Miller, a neuroscientist at MIT and one of the world experts on divided attention, says that our brains are “not wired to multitask well... When people think they're multitasking, they're actually just switching from one task to another very rapidly. And every time they do, there's a cognitive cost in doing so.” So we're not actually keeping a lot of balls in the air like an expert juggler; we're more like a bad amateur plate spinner, frantically switching from one task to another, ignoring the one that is not right in front of us but worried it will come crashing down any minute. Even though we think we're getting a lot done, ironically, multitasking makes us demonstrably less efficient.

Multitasking has been found to increase the production of the stress hormone cortisol as well as the fight-or-flight hormone adrenaline, which can overstimulate your brain and cause mental fog or scrambled thinking. Multitasking creates a dopamine-addiction feedback loop, effectively rewarding the brain for losing focus and for constantly searching for external stimulation. To make matters worse, the prefrontal cortex has a novelty bias, meaning that its attention can be easily hijacked by something new – the proverbial shiny objects we use to entice infants, puppies and kittens. The irony here for those of us who are trying to focus amid competing activities is clear: the very brain region we need to rely on for staying on task is easily distracted. We answer the phone, look up something on the internet, check our email, send an SMS, and each of these things tweaks the novelty- seeking, reward-seeking centres of the brain, causing a burst of endogenous opioids (no wonder it feels so good!), all to the detriment of our staying on task. It is the ultimate empty-calorie brain candy. Instead of reaping the big rewards that come from sustained, focused effort, we instead reap empty rewards from completing a thousand little sugar-coated tasks.

In the old days, if the phone rang and we were busy, we either didn't answer or we turned the ringer off. When all phones were wired to a wall, there was no expectation of being able to reach us at all times – one might have gone out for a walk or been between places – and so if someone couldn't reach you (or you didn't feel like being reached), it was considered normal. Now more people have mobile phones than have toilets. This has created an implicit expectation that you should be able to reach someone when it is convenient for you, regardless of whether it is convenient for them. This expectation is so ingrained that people in meetings routinely answer their mobile phones to say, “I'm sorry, I can't talk now, I'm in a meeting.” Just a decade or two ago, those same people would have let a landline on their desk go unanswered during a meeting, so different were the expectations for reachability.

Just having the opportunity to multitask is detrimental to cognitive performance. Glenn Wilson, former visiting professor of psychology at Gresham College, London, calls it info-mania. His research found that being in a situation where you are trying to concentrate on a task, and an email is sitting unread in your inbox, can reduce your effective IQ by 10 points. And although people ascribe many benefits to marijuana, including enhanced creativity and reduced pain and stress, it is well documented that its chief ingredient, cannabidiol, activates dedicated cannabidiol receptors in the brain and interferes profoundly with memory and with our ability to concentrate on several things at once. Wilson showed that the cognitive losses from multitasking are even greater than the cognitive losses from pot-smoking.

Russ Poldrack, a neuroscientist at Stanford, found that learning information while multitasking causes the new information to go to the wrong part of the brain. If students study and watch TV at the same time, for example, the information from their schoolwork goes into the striatum, a region specialised for storing new procedures and skills, not facts and ideas. Without the distraction of TV, the information goes into the hippocampus, where it is organised and categorised in a variety of ways, making it easier to retrieve. MIT's Earl Miller adds, “People can't do [multitasking] very well, and when they say they can, they're deluding themselves.” And it turns out the brain is very good at this deluding business.

Then there are the metabolic costs that I wrote about earlier. Asking the brain to shift attention from one activity to another causes the prefrontal cortex and striatum to burn up oxygenated glucose, the same fuel they need to stay on task. And the kind of rapid, continual shifting we do with multitasking causes the brain to burn through fuel so quickly that we feel exhausted and disoriented after even a short time. We've literally depleted the nutrients in our brain. This leads to compromises in both cognitive and physical performance. Among other things, repeated task switching leads to anxiety, which raises levels of the stress hormone cortisol in the brain, which in turn can lead to aggressive and impulsive behaviour. By contrast, staying on task is controlled by the anterior cingulate and the striatum, and once we engage the central executive mode, staying in that state uses less energy than multitasking and actually reduces the brain's need for glucose.

To make matters worse, lots of multitasking requires decision-making: Do I answer this text message or ignore it? How do I respond to this? How do I file this email? Do I continue what I'm working on now or take a break? It turns out that decision-making is also very hard on your neural resources and that little decisions appear to take up as much energy as big ones. One of the first things we lose is impulse control. This rapidly

spirals into a depleted state in which, after making lots of insignificant decisions, we can end up making truly bad decisions about something important. Why would anyone want to add to their daily weight of information processing by trying to multitask?

In discussing information overload with Fortune 500 leaders, top scientists, writers, students, and small business owners, email comes up again and again as a problem. It's not a philosophical objection to email itself, it's the mind-numbing number of emails that come in. When the 10-year-old son of my neuroscience colleague Jeff Mogil (head of the Pain Genetics lab at McGill University) was asked what his father does for a living, he responded, "He answers emails." Jeff admitted after some thought that it's not so far from the truth. Workers in government, the arts, and industry report that the sheer volume of email they receive is overwhelming, taking a huge bite out of their day. We feel obliged to answer our emails, but seems impossible to do so and get anything else done.

Before email, if you wanted to write to someone, you had to invest some effort in it. You'd sit down with pen and paper, or at a typewriter, and carefully compose a message. There wasn't anything about the medium that lent itself to dashing off quick notes without giving them much thought, partly because of the ritual involved, and the time it took to write a note, find and address an envelope, add postage, and take the letter to a mailbox. Because the very act of writing a note or letter to someone took this many steps, and was spread out over time, we didn't go to the trouble unless we had something important to say. Because of email's immediacy, most of us give little thought to typing up any little thing that pops in our heads and hitting the send button. And email doesn't cost anything.

Sure, there's the money you paid for your computer and your internet connection, but there is no incremental cost to sending one more email. Compare this with paper letters. Each one incurred the price of the envelope and the postage stamp, and although this doesn't represent a lot of money, these were in limited supply – if you ran out of them, you'd have to make a special trip to the stationery store and the post office to buy more, so you didn't use them frivolously. The sheer ease of sending emails has led to a change in manners, a tendency to be less polite about what we ask of others. Many professionals tell a similar story. One said, "A large proportion of emails I receive are from people I barely know asking me to do something for them that is outside what would normally be considered the scope of my work or my relationship with them. Email somehow apparently makes it OK to ask for things they would never ask by phone, in person, or in snail mail."

There are also important differences between snail mail and email on the receiving end. In the old days, the only mail we got came once a day, which effectively created a cordoned-off section of your day to collect it from the mailbox and sort it. Most importantly, because it took a few days to arrive, there was no expectation that you would act on it immediately. If you were engaged in another activity, you'd simply let the mail sit in the box outside or on your desk until you were ready to deal with it. Now email arrives continuously, and most emails demand some sort of action: Click on this link to see a video of a baby panda, or answer this query from a co-worker, or make plans for lunch with a friend, or delete this email as spam. All this activity gives us a sense that we're getting things done – and in some cases we are. But we are sacrificing efficiency and deep concentration when we interrupt our priority activities with email.

Until recently, each of the many different modes of communication we used signalled its relevance, importance, and intent. If a loved one communicated with you via a poem or a song, even before the message was apparent, you had a reason to assume something about the nature of the content and its emotional value. If that same loved one communicated instead via a summons, delivered by an officer of the court, you would have expected a different message before even reading the document. Similarly, phone calls were typically used to transact different business from that of telegrams or business letters. The medium was a clue to the message. All of that has changed with email, and this is one of its overlooked disadvantages – because it is used for everything. In the old days, you might sort all of your postal mail into two piles, roughly corresponding to personal letters and bills. If you were a corporate manager with a busy schedule, you might similarly sort your telephone messages for callbacks. But emails are used for all of life's messages. We compulsively check our email in part because we don't know whether the next message will be for leisure/amusement, an overdue bill, a "to do", a query... something you can do now, later, something life-changing, something irrelevant.

This uncertainty wreaks havoc with our rapid perceptual categorisation system, causes stress, and **leads to decision overload**. Every email requires a decision! Do I respond to it? If so, now or later? How important is it? What will be the social, economic, or job-related consequences if I don't answer, or if I don't answer right now?

Now of course email is approaching obsolescence as a communicative medium. Most people under the age of 30 think of email as an outdated mode of communication used only by "old people". In its place they text, and some still post to Facebook. They attach documents, photos, videos and links to their text messages and Facebook posts the way people over 30 do with email. Many people under 20 now see Facebook as a medium for the older generation.

For them, texting has become the primary mode of communication. It offers privacy that you don't get with phone calls, and immediacy you don't get with email. Crisis hotlines have begun accepting calls from at-risk youth via texting and it allows them two big advantages: they can deal with more than one person at a time, and they can pass the conversation on to an expert, if needed, without interrupting the conversation.

But texting suffers from most of the problems of email and then some. Because it is limited in characters, it discourages thoughtful discussion or any level of detail. And the addictive problems are compounded by texting's hyperimmediacy. Emails take some time to work their way through the internet and they require that you take the step of explicitly opening them. Text messages magically appear on the screen of your phone and demand immediate attention from you. Add to that the social expectation that an unanswered text feels insulting to the sender, and you've got a recipe for addiction: you receive a text, and that activates your novelty centres. You respond and feel rewarded for having completed a task (even though that task was entirely unknown to you 15 seconds earlier). Each of those delivers a shot of dopamine as your limbic system cries out "More! More! Give me more!"

In a famous experiment my McGill colleagues Peter Milner and James Olds, both neuroscientists, placed a small electrode in the brains of rats, in a small structure of the limbic system called the nucleus accumbens. This structure regulates dopamine production and is the region that "lights up" when gamblers win a bet, drug addicts take cocaine, or people have orgasms – Olds and Milner called it the pleasure centre. A lever in the cage allowed the rats to send a small electrical signal directly to their nucleus accumbens. Do you think they liked it? Boy how they did! They liked it so much that they did nothing else. They forgot all about eating and sleeping. Long after they were hungry, they ignored tasty food if they had chance to press that little chrome bar; they even ignored the opportunity for sex. The rats just pressed the lever over and over again, until they died of starvation and exhaustion. Does that remind you of anything? A 30-year-old man died in Guangzhou (China) after playing video games continuously for three days. Another man died in Daegu (Korea) after playing video games almost continuously for 50 hours, stopped only by his going into cardiac arrest.

Each time we dispatch an email in one way or another, we feel a sense of accomplishment, and our brain gets a dollop of reward hormones telling us we accomplished something. Each time we check a Twitter feed or Facebook update, we encounter something novel and feel more connected socially (in a kind of weird, impersonal cyber way) and get another dollop of reward hormones. But remember, it is the dumb, novelty-seeking portion of the brain driving the limbic system that induces this feeling of pleasure, not the planning, scheduling, higher-level thought centres in the prefrontal cortex. Make no mistake: email-, Facebook- and Twitter-checking constitute a neural addiction.

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