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Abstract: The article focuses on multitasking, which compromises on performance. It states that studies conducted by researchers reveal that performance deteriorates drastically when a person tries to focus on more than one task at a time. According to a study accident risk is more when the driver is using cell phone while driving that he being intoxicated. A study conducted by Clifford Nass of the Stanford University reveals that people took more time to switch tasks while multitasking.

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SUPERTASKERS AND THE MULTITASKING BRAIN

The discovery of multitasking masterminds is revealing how the brain works when it strives to do several things at once

"Any man who can drive safely while kissing a pretty girl is simply not giving the kiss the attention it deserves," Albert Einstein is purported to have said. The quote acknowledges a fundamental characteristic of human attention. Sometimes there simply is not enough of it to go around.

Never mind the buzzes and beeps of every new text message and e-mail, distracting as they may be. The pressures to be supportive family members, lifelong learners, chiseled athletes and professional leaders make multitasking nearly irresistible.

You can almost hear our collective inner monologue: there must be a way to trick time, to coerce that lengthy to-do list to start shrinking twice if not three times as fast.

Yet effective multitasking is a myth. So, too, is the idea that members of the "multitasking generation," who grew up with video games, smart phones and e-readers, can somehow concentrate on several

things at once. In fact, research indicates that frequent multitaskers are often the worst at it.

That multitasking compromises performance has been known for decades. Only now, however, are we beginning to identify some of the personality traits most commonly associated with the most flagrant job jugglers. To our surprise, we have also discovered that a small fraction of the participants in our studies appear to multitask with ease, performing cognitive feats we had not thought possible. These unique individuals have not only given us new insight into the neural mechanisms for managing multiple mental activities, they are also forcing us to rethink our theories of attention.

Know Your Limits

The human mind's limited capacity for attention became strikingly apparent with the growth of aviation during World War II. As the task of piloting an airplane increased in complexity, the amount of information that the pilot was required to process also grew -- and so did the number of airplane accidents unrelated to mechanical failures. The pioneering psychologist Donald Broadbent set out to investigate whether pilots were able to take in all the information displayed to them. Through his experiments, Broadbent found that the mind of a pilot could take in only a limited number of signals. This premise of finite attention is now a cornerstone for contemporary cognitive neuroscience, and today it is well accepted that attention is limited in capacity and can be flexibly allocated among concurrent tasks.

By this theory, however, devoting more attention to one activity necessarily implies taking it away from others. Attention is thought to amplify some signals and suppress others, two processes known as facilitation and inhibition. If your brain were a dashboard, facilitation and inhibition would be knobs that turn up the volume on relevant stimuli and tamp down extraneous sensations. Tuning attention appropriately is key to healthy cognition, and several psychological disorders stem from the failure to do so, either from difficulties amplifying the appropriate input from your eyes, ears and other senses or from trouble suppressing unimportant details of the environment. In some cases, excessive multitasking may even exacerbate attention-related psychological disorders.

For the past decade our laboratory has been investigating the phenomenon by examining how we balance driving and talking on a cell phone, a common if ill-advised habit of many people. The findings are clear: our performance deteriorates drastically when we attempt to focus on more than one task at a time. Although our interest is in higher-level cognitive activities that compete for attention, even simple acts such as walking and chewing gum can be impaired with sufficient cognitive load. In one classic YouTube video, a woman is caught on camera composing a text message on her cell phone while walking through a mall -- until she tumbles headfirst into a water fountain. The stakes can be much higher when driving while maintaining a cellphone conversation.

Bolstering the theory of a limited attention span, scientists have observed that cell-phone drivers' reactions are slower, they have difficulty staying in their lane and maintaining appropriate following distance, and they are more likely to run red lights and miss other important details in the driving environment. We recently conducted an observational study of 56,000 drivers as they approached an intersection where they were required to come to a complete stop. We found that drivers talking on their cell phone were more than twice as likely to fail to stop appropriately.

At any given time during the day, about one in 10 individuals are both on the road and on the phone.

Intersection violations are potentially hazardous events, so it is alarming to see that such a common behavior is associated with this level of impairment. In fact, we have reviewed a number of legal cases where a driver talking on a cell phone failed to notice a red traffic light and proceeded through the intersection, causing an accident that resulted in serious injuries or fatalities. Understanding when we can and cannot multitask is not just an academic exercise -- it is a matter of life and death.

Driven to Distraction

To study distracted driving in finer detail, we monitored participants using a realistic driving simulator. Using this device for a study in 2006, we found that the crash risk for those using a cell phone to talk or text often exceeds the level observed with drivers who are at the legal limit of alcohol intoxication.

Also using a driving simulator, we observed individuals' eye movements and the corresponding brain activity through electrodes attached to the scalp. We found that drivers failed to notice up to half of the items that they looked at, and we confirmed that they reacted substantially more slowly to the information that they did detect.

In research published in 2003 and 2007, we tracked participants' gaze to note what items they looked at and then quizzed subjects later about what they recalled observing. Their memory for the items their eyes fell on was only half as good while they were talking on a cell phone as when they were not distracted by the phone. A follow-up study published in 2007 found that this pattern was observed with both highly relevant items, such as a child standing on a sidewalk, and with less important landmarks, such as a billboard alongside the road. In other words, the brain does not prioritize information by its importance when deciding what is "lost" while the driver is on the phone. Lapses of attention essentially rendered the drivers partially blind to significant details directly in their gaze.

To establish that cell phones induce a form of inattention blindness, we again used electrodes on the scalp to compare the brain signals associated with the detection of illuminated brake lights on the vehicle in front of the driver. We measured the drivers' brain activity both when they were talking on a hands-free cell phone and when they were not distracted by such use.

A particularly interesting component of these brain waves, known as the P300, is a signal that is sensitive to how much attention a person is paying to a specific stimulus. The amplitude of the P300 signal increases as more attention is allocated to a task. When drivers were talking on their cell phone, we found that the amplitude of the P300 was cut in half -- a drop that reflects their decreased focus on the task of driving. The reduction in the P300 explains why drivers often fail to detect and react to events in the driving environment. Their brain is busy processing the conversation and not what they are looking at through the windshield.

Because both handheld and hands-free cell phones cause equivalent interference, it establishes that this is a form of cognitive distraction, as opposed to, say, a visual distraction that draws the driver's eyes from the road or a manual distraction that compels the driver to remove his or her hands from the wheel. Even with eyes on the road and both hands on the wheel, the individual is impaired.

This finding has implications for a recent trend in state legislation. Many states have implemented laws prohibiting the use of handheld phones but permitting hands-free cell phones. Statistics from the Highway

Loss Data Institute, a nonprofit road safety research group, indicate that such legislation has not improved traffic safety. More important, our studies suggest that the level of cognitive distraction is equivalent for both kinds of cell-phone use. These results also imply that computer-based speech-recognition systems currently being installed in vehicles are not likely to eliminate the problem.

Even so, not all distractions are created equal. When comparing the effects of being on the phone with chatting with another passenger in the car, for example, we found that the passenger and driver adjusted their conversation based on driving demands. The passenger also assisted by noting hazards and reminding the driver of their navigation goal. This real-time adjustment in the dialogue to road conditions was not observed with cell-phone conversations. In fact, drivers chatting with a passenger had no trouble getting to their destination -- in the case of our experiment, a roadside rest stop -- whereas half of the drivers on a cell phone com-pletely missed their exit.

Practice Makes Imperfect

Perhaps, you might argue, these individuals were simply not accustomed to the rigors of driving while on the phone. In this case at least, practice does not seem to lead to great gains in performance. When we compared drivers who frequently used cell phones with those who did so less often, we did not find that the first group was less impaired, and extensive laboratory practice also did not appear to help.

The reality might actually be even more dire, however, than a straightforward lack of improvement. In 2009 Clifford Nass of Stanford University and his colleagues assessed individuals on the degree to which they engaged in multitasking and timed how long it took them to switch among tasks, specifically between classifying a digit as odd or even and judging whether a letter is a consonant or a vowel. They found a negative correlation between the two measures, whereas higher self-reported levels of media multitasking were associated with longer times for people to switch between classifying digits and letters. It appears that trying to do several things at once actually diminishes your skills.

In a recent collaboration with social psychologist David Sanbomnatsu, our colleague at the University of Utah, we asked more than 300 participants to rate the frequency of their multitasking and their perceived ability to do so (relative to the average college student) and then asked them to complete a multitasking test. In the exam, participants memorized an ordered list of items and tried to keep them in mind while simultaneously solving math problems. Using standard questionnaires, we also rated how impulsive and sensation-seeking the participants were.

Our data all showed the same pattern: people who were high in real-world multitasking had lower working-memory capacity, were more impulsive and sensation-seeking, and tended to rate their own ability to multitask as higher than average. That is, their perceived ability and actual ability to multitask were inversely related. This work suggests that overconfi-dence, rather than skill, drives the proliferation of multitasking.

Whether doing several things at once depletes working memory or whether those who formed a habit of multitasking already were less adept at mentally manipulating various pieces of information concurrently is not yet known, although we suspect that both might be true. We have some early evidence that multitasking causes a kind of cognitive depletion and that "unplugging" has restorative properties.

As for what might feed the underlying motivation to multitask, one possibility, as suggested by lab studies done in 2007 by Stephen J. Payne of the University of Bath in England and his colleagues, is that individuals switching among tasks are seeking to increase the time spent on the activity that produces the most reward. That observation could well match our reports that heavy multitaskers tend to be sensation-seeking. Whatever the cause, a divided attention appears to impede performance rather than assisting it. The inability to overcome these costs is particularly salient when it comes to reacting to an unexpected event, such as a child running out into the street. But as we were about to learn, not everybody fits that mold.

Search for Supertaskers

We found our first exception to the rule completely by accident. We were comparing our study participants' scores on different tasks, such as driving alone, talking on a hands-free phone alone, and doing both concurrently. After going through the data, however, we identified one unusual subject who had virtually identical scores for doing either just one or both activities. After checking and re-checking the data, we realized that this person was multitasking in ways we had not thought possible. We continued our data collection in search of more such anomalies. After testing approximately 700 people, we have identified 19 people so far who meet the "su-pertasker" criteria, or about 2.5 percent. These individuals all ranked among the top 25 percent when doing a single task, and their performance did not deteriorate when completing two assignments at once.

To identify the neural regions that support supertaskers' extraordinary multitasking ability, we used functional MRI. We scanned 16 of our supertaskers as well as a group of subjects who matched them in their single-task scores, working-memory capacity, gender and age, among other measures. Because the driving simulator and the MRI facilities are incompatible technologies, we switched to a computerized multitasking test that required participants to concurrently maintain and manipulate separate visual and auditory streams of information.

We saw significant differences in the patterns of neural activation of supertaskers and the control group. Supertaskers showed less activity at the more difficult levels of the multitasking test. For most people, a tougher challenge recruits more resources in the brain, but supertaskers showed little or no change in brain activity as the task became more demanding, suggesting that somehow these individuals can achieve greater efficiencies and, along with it, higher performance. Our supertaskers seem to have the "right stuff," keeping their brains cool under a heavy load, just as fighter pilots are reported to do in demanding situations. Because our studies controlled for working-memory capacity, we know that working memory is important but not sufficient to account for superior multitasking abilities. Supertaskers differed most strikingly from control subjects in three frontal brain areas that earlier neuropsychological research on multitasking had flagged: the frontopolar prefrontal cortex, dorsolateral prefrontal cortex and the anterior cingulate cortex. For us, the most intriguing brain region that differentiated supertaskers from controls was the frontopolar cortex. Comparative studies with humans and great apes indicate that this area is relatively larger and more richly interconnected in humans, whereas other frontal cortical areas are more equivalent in size and connectivity. The emergence of humans' multitasking ability, however flawed, might be a relatively recent evolutionary change in homi-nid brains, helping to distinguish humans from other animals. In addition, neuropsychological patients with more extensive frontopolar damage have been shown to be more impaired in multitasking. Now we know that high levels of efficient processing in

these regions support extraordinary multitasking ability, bringing us one step closer to finally developing a model of how the brain multitasks.

The examination of individual differences in multitasking ability is a relatively new enterprise, however. Whether supertaskers are just an extreme on a continuum or are qualitatively different is still an open question.

The Multitasking Advantage

To tease out what distinguishes these brains, we are now looking for differences in the connections among regions in the supertasking brain as well as hunting for unique features in their genetics, either of which could lead to more efficient processing for these individuals. Variants of one particular gene, catecbol-O-methyltransferase (COMT), for example, are associated with differences in working memory, executive attention and a slight predisposition to a broad number of psychological disorders.

One reason to examine this gene is that its variants alter how efficiently the neurotransmitter dopamine can operate in the frontal cortex, which encompasses the brain regions that support multitasking. It is thought that lower COMTenzyme activity may result in greater availability of dopamine for binding at receptor sites in the frontal cortex. By sequencing the DNA in samples of our supertaskers' blood or saliva, we have found preliminary evidence suggesting that these individuals possess a variant of COMT that leads to more efficient dopamine signaling in the regions of the brain supporting multitasking. We are still investigating whether the features of this gene might explain supertaskers' superior powers of attention.

To expand our research, we will need to find more supertaskers. It is intriguing to consider where we might find them -- that is, which occupations might ideally suit supertaskers. Pilots of high-performance aircraft are good candidates to be supertaskers. So, too, are high-end chefs who can cook several meals at the same time to perfection. Perhaps some of the star quarterbacks in the National Football League are supertaskers. Champion video gamers may also be a good bet, as are the elite doctors in hospital emergency rooms. All other things being equal, we suspect that supertaskers will rise to the top in any occupation that places a high demand on juggling various attention-demanding tasks at the same time.

Exploring why the supertasking mind excels where the rest of us fail might help us structure tasks so they do not overtax the brain's abilities, such as using auditory cues in contexts where visual information is overwhelming. The research can also add more nuance to our understanding of attention-related psychiatric problems, including obsessive-compulsive disorder, thought disorders and attention-deficit hyperactivity disorder.

Given the rise of technology over the past few generations and the role it has played in making frequent multitasking possible, one might ponder the potential long-term consequences of a society that places such high value on this skill. Returning to Einstein's observations on driving and kissing -- or talking on a cell phone -- the vast majority of us cannot multitask without significant costs. In the very distant future, supertaskers' ability to better cope with multiple goals and information sources may be an increasingly adaptive feature in the evolution of our species.

FAST FACTS

Multitasking Demystified

1.Attempting to complete two or more tasks at once 1 causes us to divide our attention, so that we focus less on each of those activities.

- 2. A Person wno drives while talking on a cell phone, for example, is a worse driver than an individual at the legal limit of alcohol intoxication.
- 3. A small percentage of the population defies this trend and multitasks with ease. These so-called supertaskers are helping to elucidate the underlying brain mechanisms supporting multitasking and attention.

Tuning attention properly is key to healthy cognition. Several mental disorders stem from the failure to amplify or suppress details of the environment.

Frequent multitaskers tend to be more impulsive and sensation-seeking, as well as overly' confident in their ability to juggle mental activities.

The emergence of our multitasking ability, however flawed, might be a relatively recent evolutionary change helping to distinguish<FT.-humans from other animals.

(Further Reading)

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(The Authors)

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Daniel Broadbent, a pioneering psychologist who first characterized attention as a limited commodity, was inspired by watching pilots manage overwhelming amounts of information.

The simulator used by the authors re-creates a realistic driving experience. Subjects wore caps dotted with electrodes to measure their brain activity under various conditions, including while talking on the phone.

Supertaskers are able to juggle multiple mental activities effortlessly. A super-tasking chef, for example, might be particularly adept at simultaneously preparing numerous dishes to perfection.

The frontopolar regions of the brain (ye/low) may be recruited during multitasking.

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By David L. Strayer and Jason M. Watson

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