PARENT & FACULTY EDUCATION CONFERENCE

The Distracted Mind

Adam Gazzaley, M.D., Ph.D.

Attendee Notes for Menlo School Workshop: Feb. 9, 2013

Adam Gazzaley, M.D., Ph.D., is the founding director of the Neuroscience Imaging Center at UCSF, an Associate Professor in Neurology, Physiology and Psychiatry, and Principal Investigator of the cognitive neuroscience laboratory, which studies neural mechanisms of perception, attention and memory, with an emphasis on the impact of distraction and multitasking on these abilities. Dr. Gazzaley's unique research approach utilizes a powerful combination of human neurophysiological tools, including functional magnetic resonance imaging (fMRI), electroencephalography (EEG) and transcranial magnetic stimulation (TMS). Author of over 70 scientific articles and international speaker, his PBS-sponsored special "The Distracted Mind with Dr. Adam Gazzaley" was recently broadcast across the nation. More information about Dr. Adam Gazzaley may be found at gazzaleylab.ucsf.edu.

The Refrigerator Problem. In the conference opening panel discussion, Dr. Gazzaley discussed the very common "refrigerator problem," that moment when a person goes to the refrigerator for a specific reason, but upon arriving there is unable to remember what that reason was. He launched his workshop talk by saying that the refrigerator problem is not really a memory problem after all.

The Amazing Brain. The brain is "the most complicated structure we know in the universe." It is capable of rapid perception and handles a massive amount of date -- the equivalent of 50,000 times the text stored in the Library of Congress over a lifetime. It contains 100 billion of neurons, but even more impressive is the network of hundreds of trillions of connections. Everything we do and feel is a function of the brain, including our sense of identity.

Brain Functioning Has Limitations: In spite of its extraordinary capabilities, the function of the brain is limited in several ways, specifically attention, working memory, processing speed, and sensitivity to interference.

Humans are good at spotlight or selective attention such as the "cocktail party effect." A person in a conversation at a party may find him/herself bored, and s/he can easily switch attention to an entirely different conversation. We are not as capable, however, of widely distributed attention (like a net).

We are also limited in our ability to do parallel processing. And, because of the multitude and complexity of the connections in the brain, processing speed is limited.

Working memory is also limited. An example of working memory is a person's ability while in a conversation to hold a thought until the other party is finished speaking. [Example cited: telephone numbers were said to be limited to seven digits because that was thought to be the number of digits a person could hold in their head (in the days when that used to be necessary.]

The brain is sensitive to interference; it is a question of attention rather than memory. Interference can be internal or external. The two types of external interference are: distraction – irrelevant stimuli you are trying to ignore – and interruption, which is equivalent to multitasking in that you want to attend to this stimulus in parallel to your goal. Internal interference may be categorized as either intrusions and mind wandering or multitasking.

Our technology-permeated world has changed societal expectations to include immediate responsiveness and continuous productivity.

Perception and the Brain. Perception is not the same as sensation. Perception is always an interpretation. External, stimulus driven attention is “bottom/up” attention. This is what we typically see in animals, even when their behavior seems goal driven. An example of bottom/up attention in humans is that people will automatically orient to their name if they hear it mentioned anywhere in their vicinity. Bottom/up processing takes place in the occipital lobe of the brain.

In contrast, “top/down” perception is what humans normally use, and it affects both working memory and long term memory. Top/down perception allows us to choose what we want to attend to.

What is cognitive control: does it mean you are focusing better or are you ignoring better? They are not two sides of the same coin, as originally thought, but rather they function independently; you can focus well but ignore badly. [In the example of the cocktail party slide, the man is attending to a different conversation. It is not his goal, but he is doing it anyway.]

What you see gets processed in the back of the brain (occipital lobe) but it is interpreted by the prefrontal cortex. In top/down perception, the prefrontal cortex processes information differently depending on its relation to your goal.

The relative size of the prefrontal cortex is the hallmark of what makes us most human: this ability to do top/down processing. As mentioned earlier, animals are not really as goal-oriented as we think they are; they are really bottom/up processing, reacting to their environment. The proportion of brain occupied by the prefrontal cortex increased over the history of evolution.

The prefrontal cortex provides a buffer that allows us to pause to make a decision as opposed to reacting directly. We want to be able to send our attention everywhere, but we run into the limitations described above.

We feel the burden of interference in our daily lives, but technology increases the burden. The prefrontal cortex is also the latest part of the brain to develop as we age over the course of our lives. This explains why teenagers do more bottom/up processing. They may have a goal, but

the goal can easily be interfered with. Another example: Dr. Gazzaley watched a toddler appearing to be very goal driven when approaching a toy, but becoming immediately and completely diverted when the TV was turned on. So, the processing was really bottom/up.

Cognition reacts with/affects many aspects of our lives, including safety, development, family, work, education, and social skills.

Dr. **Gazzaley's Lab.** In the lab, Dr. Gazzaley studies how attention and memory interact, for as Samuel Johnson said in 1759, "the true art of memory is the art of attention."

Lab experiments test both younger subjects (ages 18-35) and older subjects (ages 60-80) using functional MRI (which shows where in the brain activity is occurring) and EEG (better at showing the timing of brain activity).

Study on Impact of Distraction and Multitasking on Memory. Study participants were shown brief images of neutral faces followed either by no interference, by a distraction, or by a multitasking task. Then they were shown another face and were asked if it was the same as the first face they saw. Distraction created a decrease in working memory, but multitasking intervention created an even greater decrease. The effect was increased with older study subjects compared to younger ones.

In another study, subjects were shown an image of objects like crowns, then some interfering images, then later in the MRI they were asked about the crowns and told to use mental imagery to remember how many crowns they were originally shown. Just having their eyes open decreased their memory of the number of crowns. Is that because the interference was visual? No, because when the distraction was auditory, the results were the same.

Conclusion: Our cognition is exquisitely sensitive to distraction, and the distraction effect is greater with older people than with younger.

The Prefrontal Cortex. The prefrontal cortex acts as a "bouncer" or filter via its connection to the visual cortex. If too much gets past the filter, memory retention will be less. The prefrontal cortex also acts as filter for interruptions vs. distractions. In this, it acts not as a bouncer but as a "flight controller," determining what the priority is at a given moment. Multiple tasks create a bottleneck. Like a bike messenger in traffic trying to text at the same time, people attempt to multitask, but not successfully. With each switch between tasks the performance gets worse. There is a time delay caused by switching tasks that leads to decreased performance.

The Myth of Multitasking. In reality, it is a myth that multitaskers are engaging in multiple tasks simultaneously if the tasks require a lot of cognitive resources. A Stanford study found that heavy media multitaskers are more susceptible to interference from distractors and less effective at task switching, even though they thought they were quite good at multitasking. This is an interesting finding because people usually do what they are good at but in the research people who are better at multitasking do it less, possibly because they have more cognitive control.

Multitasking is an apt topic for research, as 95% of the population uses multiple forms of media simultaneously. We don't know the long-term impact on cognition from chronic interference.

Impact of Distraction on Driving. Hands free phone use while driving makes little difference when compared to holding the phone. Studies show that talking on a mobile device while driving creates a fourfold risk of accidents, whether or not the driver is using a hands free device.

Nowadays, people include on their resumes that they are good at multitasking, but what is the effect in the workplace? Studies show that workers typically focus for 12 minutes on a project, and each project is interrupted every three minutes. Often the interruption is an internal choice rather than a ping from someone else requiring our attention. There is an economic cost to this level of interruption.

Why Do We Multitask? "FOMO" (fear of missing out) is very powerful, especially in children. MORE FUN - there may be a dopamine effect, similar to what occurs in addiction.

So, What Can We Do? Since we cannot change our brain, we must change our environment.

- Shut your door
- Curtail your email program
- Turn off your phone

Dr. Gazzaley has made deliberate changes in his own life as he has become aware of his own susceptibility to distractions and interruptions. He exercises his ability to choose by eliminating distraction when working on highly important tasks, while he allows himself to multitask when doing boring tasks.

He is designing a video game with Lucas Arts that involves a driving task and various distractions. The game allows the researchers to look at brain activity and cognition. They have subjects train for 12 hours, followed by a repetition of the task. When they ran the experiment using older adults they found that the older they were, the worse was their resistance to distraction. Even so, after training their performance got way better, and some of the improvement was still demonstrated at the end of six months. The subjects also improved on working memory and retention.

Dr. Gazzaley's company is currently creating an iPad game with ADHD kids as their first targets. The goal is to help them to multitask better.

The Takeaway. By understanding how the brain works we can guide our decision-making to improve the quality of our health and other aspects of our lives.

Q&A, final comments

Emotional component of stimuli makes them more impactful; in the lab they try to flatten emotional aspects when doing experiments.

What about listening to music while doing homework? Music is interference. There is no definitive answer, but it seems as though when it works, it is because of emotive or arousal effects. Music may be more effective with no words.

Dr. Gazzaley recommends that kids need more down time. This does not mean playing video games as a break from homework. He means shutting off goal-directed activity, because using top/down cognition is draining. Experimental subjects were more refreshed by viewing nature photos than by texting or emailing, which are still goal-oriented activities.