

## Transcript of Cerebrum Podcast— The Multi Costs of Multitasking

**Guest:** Anthony D. Wagner, Ph.D., is a Lucie Stern Professor in the social sciences and chair of the Department of Psychology at Stanford University. He is on the board of Stanford's Center for Cognitive and Neurobiological Imaging, is a contributor to the Stanford Program in Neuroscience and Society and is a faculty affiliate of the Wu Tsai Neurosciences Institute, Symbolic Systems Program, Human Biology Program, and Stanford Center on Longevity. His research focuses on the psychology and neurobiology of learning, memory, and executive function in young and older adults. In addition to his basic science and translational work, he examines the implications of neuroscience for law (including as a member of the MacArthur Foundation's Research Network on Law and Neuroscience) and the relationship between multitasking and cognition. He is a reviewing editor at *Cerebral Cortex* and serves on several other editorial boards. He received his Ph.D. at Stanford University and his Bachelor of Arts degree at the University of California, Los Angeles.

**Host:** Bill Glovin serves as editor of *Cerebrum* and as executive editor of the Dana Foundation. He was formerly senior editor of *Rutgers Magazine*, managing editor of *New Jersey Success*, editor of *New Jersey Business magazine*, and a staff writer at *The Record* newspaper in Hackensack, NJ. Glovin has won 20 writing awards from the Society of Professional Journalists of New Jersey and the Council for Advancement and Support of Education. He has a B.A. in Journalism from George Washington University.

Bill Glovin: Hi, and welcome to The *Cerebrum* Podcast where we explore topics about brain science. Today, we're going to explore what happens to your brain when, to borrow an expression from my late mother, "you are running around like a chicken with its head cut off. "I am saying it calmly, but she was less calm to say the least. And I could channel my mother saying it, but I will spare you.

Today's very special guest on the phone to talk about what the expression means and more, is Professor Anthony Wagner, chair of the Department of Psychology at Stanford University and co-author of our most recent *Cerebrum* article, ["The Multi Costs of Multitasking."](#) Dr. Wagner's research examines learning, memory and function, but also the relationship between multi-tasking and cognition. I think it is safe to say that we are all at times challenged by what seems like a million things coming at us at once, often with deadlines. Dr. Wagner's article looks at such questions as what happens to your brain when this occurs? Does your brain slow down? Does this create dangerous levels of stress and anxiety? Even depression? And finally, why are some people better at it than others?

Bill Glovin: Originally, we were scheduled to do the podcast last week, but Dr. Wagner ran into car trouble and it sounded like he was running around like that chicken I

mentioned. I hope that is all straightened and it did not set you back too badly in the pocketbook. Welcome to the podcast.

Anthony Wagner: Thank you, Bill. It is good to be here. No comment on the pocketbook.

Bill Glovin: I never know how formal to be in these podcasts. Is it okay to call you Anthony?

Anthony Wagner: Of course.

Bill Glovin: Great. So, let us start why the research is important.

Anthony Wagner: Well, the research on multitasking both from a neuroscience perspective and a psychological science perspective is important for a number of reasons. First, as we all try to navigate our modern lives in the modern technological world, we all find ourselves increasingly multitasking. Multitasking often with media, but also with other kinds of content. And one can wonder, are we, when we are multitasking, are we being as maximally efficient and effective as we could be?

In addition, the study of multitasking focuses on and reveals a number of core, or fundamental sort of aspects, of the human mind and brain. It taps into key psychological cognitive processes of attention, memory, and how we resolve and set our goals, meet our goals and resolve interference when we are attempting to do so. And so, by studying multitasking, we can actually get a deeper understanding of the way the mind and brain works and we can understand when there are changes to and challenges for particular cognitive neural systems.

Bill Glovin: I am wondering if multitasking is tied into brain development and plasticity, and if so, how does it evolve from our formative years into other stages?

Anthony Wagner: Well, I am going to push back actually on the premise of the question, if you will allow me to do that and to do that so early in our discussion. I think in some respects, the angle that you use with respects to plasticity perhaps taps into this desire or this belief that we can get better at multitasking, that it is a cognitive capability that we can acquire skill with, and actually overcome the potential costs of multitasking. And so, we can, when we are in this discussion I hope we will spend a little bit of time on that.

The second aspect of your question which is, a broader question about development and the relationships between the kinds of systems that we draw on to multitask and neural and psychological development. And so, taking this latter aspect of your question up, we know that multitasking again, as mentioned a moment ago, to multitask, it is really to kind of switch and it entails setting multiple goals, switching between those goals, using those goals to harness the networks of attention that we have in our minds and brains to point them at and to shine the spotlight on information that's relevant to our goals

and to filter out or not suffer from interference from information that is not goal relevant.

And so these systems that enable us in a goal-directed manner to represent our goals to point attention in a goal-directed way, they developed in our early sort of first couple of decades or so. And so when we are younger, it is harder to set goals, to use goals, to engage in the world in a directed manner, to allocate attention to things that really matter to us and not to have our attention captured by irrelevant things. And so there is a developmental trajectory where we do get better as these core cognitive and neural systems that support attention, goal representation and even memory as they develop, we do get better at multitasking or at task switching as we get better at other sort of aspects of life that require cognitive control or executive function.

Bill Glovin: So, is it experience? How do we get better at it? Is that with age, maturity? Do all these things factor in?

Anthony Wagner: Well, on this latter as you mentioned of your question, it is the developmental trajectory of our brains. And experience does sort of shape and tune the system. But there are multi-decade, often up into our, the current data are suggesting into our low to mid-20s where the systems that are critical for representing goals and using attention in a goal-directed manner, their developmental sort of time course is quite extended. They are in fact, the latest or developing neural systems and cognitive systems in the human sort of mind and brain. And that I think is again, experience might have some sort of effects around the edges, but I think that these are sort of well sort of established sort of developmental trajectories that occur generalizing across a whole different set of kinds of experiences.

Bill Glovin: I was just having an interesting discussion with a friend of mine at lunch who runs a small horticulture contracting company, and I was asking him, I guess he runs a few crews and whether or not his multitasking ability has gotten better in age, and he was saying how he thinks it does, and also pointed out there were at least 20 things that he was multitasking about this morning between let us say eight, nine o'clock and that he really enjoys that aspect of his job.

And I was saying that in some of my work, especially the writing part, a lot of times when I have been writing a story and I have been interrupted, I find that to be quite annoying. So, I am wondering, if it comes down to task, in other words some tasks take much more concentration than other tasks. Does multitasking deflect from let us say my writing task. Is it going to cause me to write an inferior story because I am interrupted so much? Whereas for my friend, it actually helps him do his job better.

Anthony Wagner: So, that is a great question and an interesting question plus it taps into a couple of things that we should understand and think about when we are thinking about multitasking. At the highest level, we could spend a moment dwelling on the sort of point I have mentioned a couple of times which is most of the time

when we believe we are multitasking, really what we are doing is we are task switching. That is, we are doing one task, we are representing what our goals are for that task. We are engaging with information that is relevant to that task. And then we are trying to switch into a different task, bringing up the goals, recovering the goals from memory for that task, harnessing attention to focus on the relevant information for that task.

And then we might switch to a third task. We might switch back to the initial task. And so, much of the time, probably most of the time when we are multitasking, that is what we are doing. We are really task switching. The human brain does not really multitask well most of the time. And we are not able to do that. And there are costs then of multitasking or task switching, and the cost will in part depend upon the relationships between the tasks that you are switching back and forth between. One cost that you almost always suffer is the cost of reestablishing, retrieving from memory, "Oh yeah, right. What was my goal for this portion of the document that I'm writing? What am I trying to argue?" And you have to kind of load that back in from memory when you have switched off of the task to do a second task, and now you are going back to it.

So, you are paying this cost for reestablishing information in mind that you are going to use to govern how you then continue with that task. Another cost, and this is where it becomes often quite important in terms of a particular combinations of tasks you are switching between is a memory cost. Often when we are switching between tasks, information that we use or that was activated in mind and then recently laid down in memory or recovered from memory to perform task two. That information is still present or quickly keeps popping out of memory as we are trying to perform task one. And so, it competes with and it interferes with our ability to actually focus on the information that is relevant for task one, and to achieve it. And the more similar the tasks are and the knowledge in the two tasks are, the more there is going to be interference. This is kind of demonic interference, the interference between the tasks.

So, there then the combinations of the task, how similar they are in terms of goals, the kind of knowledge being used, et cetera. What impact the degree to which this task switching is costly. It will always be costly. But it could be more costly the more similar the tasks are.

Bill Glovin: Fascinating. Yeah, go ahead.

Anthony Wagner: Now going back to, so most of the time that is what we mean when we talk about multitasking, we are really task switching. But there are times in which it is clear that we are multitasking. You could be driving down the road in your car and you will be carrying on a conversation with somebody in the passenger seat, or hopefully not, but you may choose to be carrying on a conversation with a person on a cell phone. And there you are doing two things in theory. You are doing two things at once. You are continuing to drive that car as you are carrying on conversation. Part of the reason you can do this kind of multitasking is because driving the car under most conditions draws on highly automated,

very habitual responses that require limited attention and limited representation of goal states.

And so, this is how you can end up getting in your car, driving home, and you might have been distracted by some work related thoughts or event or planning for what is going on that evening, and you might pull into your driveway and you might kind of have this, "Wow, I don't even remember anything about my drive home." Because you were minimally using attention in a goal directed manner to engage in the aspects of your drive because that attention was internally focused on your thoughts.

So, that kind of multitasking can occur where you have combining a highly automated set of behaviors such as driving behaviors with something that is more attentionally demanding like having a conversation. Where that goes awry is when that the conditions in which you are performing the highly automated task, the driving, require now the focused allocation of attention, it is to detect that kid who is popping out from the sidewalk between two cars chasing a ball into the road. You need to detect that, have attention rapidly shift and then to deploy attention to sort of implement strategies to respond to that situation. Similar to other conditions with respect to the road, there is construction, et cetera. And it is under those conditions where we often, we might have fooled ourselves into thinking, "Ah, lo and behold, look, I've driven home many times talking on my cell phone and I've not had an accident. I've not hit anybody."

But it is under those circumstances in which you need to shift out of this sort of automaticity of driving to be attentive and engage in a reactive goal-directed manner to unexpected circumstances. It is under those conditions where you realize it is actually remarkably dangerous, and the data tells us it is remarkably dangerous to drive while carrying on that conversation with somebody on the cell phone. They cannot read the conditions. They cannot react to them. And they are distracting you. And the data tell us that even with hands free cell phone use, it is as if you are legally intoxicated. The risk that you have for yourself and for others under those circumstances is incredibly high.

- Bill Glovin: So, it sounds like it really does depend on the task at hand in terms of-
- Anthony Wagner: It depends on the task at hand, the combination of tasks, and how skilled and how automatic your behavior might be able to be in one or both of those tasks.
- Bill Glovin: Is that even measurable? I mean, how many tasks is too many? And can we know that? Or it just depends on the tasks?
- Anthony Wagner: It will depend on the task, and it will depend on how we navigate life. The reason that we are multitasking, or we are task switching a lot is because there are many demands on us, right? And it may well be that the right cost benefit analysis for you at a given moment in time is to engage in task switching, is to multitask your boss or a client that needs something from you right now, and it

is different from the tasks that you are currently working on. The right cost benefit calculation for you may well be for you to pay the price that you are going to pay to switch back into the task you are currently doing, but the shift over to that other task that now is more important, it is primary.

Bill Glovin: So, let us take two people with the same sort of cultural background, same education and experience. Why would one be better at multitasking than the other?

Anthony Wagner: Well, there is variance in the human population with respect to genetic neurochemical and maybe even experiential backgrounds that are relevant for task switching for executive function or this other jargony term, cognitive control, the ability to control cognition to bring it to bear to meet our goals. And the same educational background and other sort of demographics does not mean that critical genetic or neural sort of factors that influence how effective you are, what you are inclined sort of functional capability is with respect to attention and control. They still can differ.

They can also differ in theory, and this is a currently hot topic within our culture, and we do not know the answer in terms of cause and effect. But many worry that they can differ because of the choices that we make in terms of engaging without modern world. So, there is increasing question and concern and there is a lot of hype with limited data about the ways in which we engage with media, with technology, and whether those activities might actually be changing individual's abilities to or the probabilities with which they are able to engage in goal-directed sustained attention. And so, work from our lab and other labs have shown simple relationships correlations was not a, we do not know anything about causality. But individuals who perhaps are coming from very similar sort of life experiences in terms of age, education et cetera. One individual might task switch, might multitask quite a lot with media. Another individual might not multitask with media much when the individuals engage with one medium. They might maybe switch between it and another channel a bit relative to the other individual who is a high media multitasker.

And me and others have accumulating data showing that in everyday life individual differences and the degree to which one is engaging within media multitasking, they are correlated with individual differences in the ability to sustain goal-directed attention, and we believe a consequence of that different in the ability to sustain goal directed attention is also that it spills out and has a consequence for keeping information active in mind in what we call working memory and building new long-term memories.

So, what looked to be two individuals who might have very shared or common experiences, they nonetheless could differ for potentially many reasons in terms of their underlying cognitive leveraging of their underlying cognitive abilities and attention or maybe even what their attentional capabilities are. And so, we are exploring that society is very concerned about the possible influences of multitasking and multitasking with media on cognition, on attention and

memory. We do not have any data as to bear on whether or not those activities are causing potential differences. But we do know that individuals who tend to be more heavy media multitaskers, they tend to struggle with sustained attention with consequences for memory.

Bill Glovin: So, if I am, here is a hypothetical, I am a surgeon and I really need to be laser focused on, and I do eye surgery. And this is in line with I guess what you were talking about in terms of goal directed, and everything outside of my surgical practice as I gain more experience is pulling me to multitask. And I find that my mind is beginning to wander when I do surgery because I have got all these other things that are suddenly coming into play. Are there ways or any practices that would help me to remain laser focused?

Anthony Wagner: Absolutely. That is a great question. There a couple of, this is now we are in speculation territory. But maybe a couple of things I might say. The first is one thing that is interesting, and you might have these conversations sometimes. You are talking with a nerdy scientist who uses a lot of field specific jargon, right. And so, our conversation a moment ago about this distinction between the probability of having an attentional lapse versus having a fundamental difference in one's attentional capacity or ability, I introduce that as a set of jargon, right? But that bears in some sense on your question another aspect of the literature. One could wonder do individuals who are heavier media multitaskers, do they have lower attentional capability such that when faced with a very challenging condition such as a very complex surgery, they are underpowered in terms of attention. Or is it that they are attentional capabilities are comparable to those who are lower media multitaskers, but under certain conditions they might just be more likely to suffer lapses of attention. That is, they do not harness their attentional abilities to perform the current task.

And what is interesting in the literature is that there is an emerging hint in the data that suggests that heavier media multitaskers tend to underperform lower media multitaskers, not on really hard complex tasks where everything is telling you that you need to be laser focused on that single thing. They often are doing okay there. It is on these sorts of slightly easier conditions where they seem to underperform. That kind of leads you to believe, or that suggests that it is not a difference in attentional capability. It is that perhaps through learning, individuals who are frequently task switching between media and getting rewarded perhaps through doing so, they have become conditioned to allow or maybe not allow, allow kind of suggests a willful sort of choice. But they become conditioned to have these sorts of lapses of attention under conditions where attention is useful, it is helpful. But you are not pushed to the wall where, oh boy, I have got to keep attention focused.

So, that is what is actually emerging, and it is an interesting sort of pattern in the literature suggesting that well, if there is this relationship, it may not be about core attentional capability. It is about the way in which we allocate

attention and perhaps we allow attention to drop off and to mind wander or switch into a different sort of cognitive state.

So, that is one aspect of the answer. The other, and we do not know yet, another interesting, and this is something that we are very intrigued by, I think, in the long run sort of the same technologies, or the rapid pace of technology that is sometimes creating contexts in which it is challenging for us as cognitive beings can also be part of the solution. What we are doing and what is emerging in the field is that there are very simple biological markers of lapses of attention. Our pupil diameter, the size of our pupil and the rate at which and the frequency with which our pupil diameter changes, those are markers of lapses of attention.

Similarly with electrodes placed on the scalp, electroencephalography, you can pick up on oscillations and neural signals that also seen to be markers of lapses of attention. And we are observing that in fact individuals who are heavier media multitaskers show these lapses of attention with a higher probability as picked up with pupillometry, measuring pupil size and with EEG. And we have also shown that in fact these lapses of attention are negatively related to task performance and to learning from the tasks that you are performing.

Well, to the extent that these then are biological lapses of markers of attention, it may be possible that you can leverage pupillometry, leverage mobile EEG to get a real time measure of an individual's attentional state and their preparedness to learn or their preparedness to perform a task like a surgery. And there may well be in the future an ability to harness these signals to capture them in real time and then to provide feedback to the individual to reorient that individual be it a student in a classroom, be it say your hypothetical surgeon in the operating room to reorient their attention back to the task at hand by sending them a signal noting that is basically a flag for them that your attention has lapsed, get back on the task, be prepared to learn, be prepared to perform the task that you are currently performing.

Bill Glovin: Fascinating. I'm just assuming that multitasking does not factor into educational strategies in any way. Are we taught to do it or should we be taught to do it? Or not to do it?

Anthony Wagner: This brings us full circle to the start of the conversation we had, right, which is I think part of the subtext of your questions is can I learn to be a better multitasker? And it is true that as cognitive beings, we develop skills in all kinds of task spaces. We talked about becoming a skilled driver and how that then allows us to engage and drive in a more automatic mode much of the time. Of course, athletes are quite skilled in the spaces they perform in artists are quite skilled. Each of us in our areas of expertise, our career areas of expertise are quite skilled. And it is also true that we acquire, over life, we acquire metacognitive knowledge. We become skilled in harnessing our cognitive systems. When we are younger and when we are very young, when we are 10 maybe younger than 10 or 12, I do not remember the exact date in this classic

study, but when we are younger and we are asked to keep something active in mind, I will give you a phone number and I want you to report it back to me 20 seconds later, we think we can do it. And what you and I would do because we have learned, is we mentally rehearse. We keep the information active in working memory.

Younger children do not adopt that strategy. They lack the metacognitive knowledge or skill to know the way in which their cognitive systems work and how to harness them, what to do to meet the task demand. You can instruct the child, "Why don't you say it, repeat it out loud for me," kind of keep it active, rehearse it, and the child would do that. Lo and behold, the child will be able to report the phone number back after the delay. But left to the child's own device, the individual lacks this knowledge and they will not engage in rehearsal and they are more likely to forget the information.

So, there are things that we can learn I think with respect to how to switch back and forth between tasks a little more efficiently. All of that said, we are still going to pay a price. There is still a cost of multitasking. You can never overcome fully those costs associated with competition between different kinds of memory traces as well as the cost of having to load back in your goal for task one that you were performing previously but then you switched out to task two and lost your goal task one and now you are going back to task one.

Bill Glovin: How about sleep and mood? I would think if I am in a great mood, I am going to be able to multitask better. If I have a great night's sleep, I can do it better. If not, is it affected. Is that part of what goes on in the research?

Anthony Wagner: Well, those are not areas of expertise per se for me, but I can say the following: One, we know that our ability to engage in goal directed behavior, our ability to allocate attention to achieve our goals is negatively affected by sleep deprivation, by poor sleep health. And so, these systems of executive function or cognitive control and attention, they are negatively affected by poor sleep. And because they are drawn upon to allow us to solve the problem of task switching or multitasking, then there is a degradation in multitasking ability when one is sleep deprived. And I suspect often many accidents are the consequence of human error, and some of those accidents come about because the individual's sleep deprived and perhaps is in a situation in which they are switching back and forth between different tasks.

With respect to mood, there are many effects of mood, including on some of the systems like these executive function or cognitive control systems. Mood can have an effect on those systems in part by drawing attention away to perhaps sad or negative thoughts upon which we are ruminating, pulling attention or resources away from the tasks and the goals that we are currently trying to achieve at the present moment. And there are other sort of consequences of depression and mood as well on executive function, but that is just one example.

Bill Glovin: Okay. And I know you are a little strapped for time, so I will try to get to these last questions quickly.

Anthony Wagner: Okay.

Bill Glovin: I have read some articles that suggest that multitasking lowers IQ. Do you believe that?

Anthony Wagner: I do not know that literature, and so I am going to stay neutral with respect to whether I believe it. But I will say that the heart of that question goes back to the issue that I was, I do not want to say dancing around, but I was trying to introduce kind of explicitly, which is we do not know if there is a causal arrow from multitasking or in the more constrained space, multitasking with media, we do not know whether there is a causal area between such behavior and changes in attention and working memory and long-term memory.

We do know the following: We know that in fact there is a strong relationship between working memory capability, working memory performance, the ability to keep information active in mind and compute over it, manipulate it, transform it and measures of IQ. There are very strong correlations between the two. We also know that this what we think of as cognitive ability, working memory, it is actually not a primary for my view of the way the mind works. It is not a primary mnemonic function it is the consequence of attention and attentional systems as well as goal representation. It is a consequence of the harnessing of those cognitive processes and the brain's ability to represent things that were out there in the world or as internal representations. And so, by pointing attention to these internal representations of things that had been out there in the world, that is what allows us to keep that information active in mind and to work over it.

And so, given that we know that IQ is strongly correlated with working memory ability, and that working memory is this emerging byproduct of goal representation, attention and the representation of the world, there is the possibility if multitasking has a causal negative drag on attention-based performance, there is in theory the possibility it could have a negative consequence of IQ. I do not know of any data. Granted, I have not explored that part of the literature closely. I do not know of compelling data that makes that point. Maybe they are out there. And it is hard science to do to really test for that causal direction. So, I am remaining neutral to your question, but wanted to share the relationships between IQ, working memory and attention and goal directing cognition.

Bill Glovin: I mean, it could be tied to sort of our propensity to rely on social media, screen time. A lot of academics that I have talked, I used to work at Rutgers as an editor. I used to complain that their students did not read as much, were not quite as focused as they had been because there were so many things coming at them at once that their attention spans were depleted, and that I think factors into that kind of IQ question somewhat.

Anthony Wagner: Well, that is the big scare, right? That is the big worry. That is what is driving this literature on multitasking with social media and other media channels, is that actually creating an increase in attention deficits and associated consequences for other systems like working memory and maybe IQ et cetera? And that is where I was trying to be very explicit that the negative relationships between goal directed allocation of attention, intentional lapsing and heavier media multitasking often, but not exclusively, but social media, email, chat, streaming services, all the, there are negative relationships.

But we do not know whether, in fact, it is the engagement within media multitasking that is giving rise to those negative relationships or they are tapping into preexisting differences in individuals in terms of attentional performance, and that those differences predispose an individual to be more likely to multitask, to be more likely to engage with multiple media channels and switch back and forth between them. We just do not know the answer to that. It is probably a mix of both, but that is speculation.

Bill Glovin: So, that is something that further research may help us uncover. Are there other things that further research will help us, will reveal that's important to this subject?

Anthony Wagner: Well, this is going to be a little repetitive, and it is partly just revealing where I as a scientist hope to go and hope that the field will go. I am hopeful and am a true believer that taking on real world problems like this question of is engaging with our technology and with media and engaging in media multitasking, is that related to differences in attention and memory? That by taking on that set of problems, real world problems, in pursuing and trying to answer them, we do sciences that provides a deeper understanding of just the way our mind/brains work such that we can understand how a goal representation and attention and attentional lapses and therefore losing our goals, how they come about, we can figure out ways to detect when they come about. We can understand the consequences of such lapses, such as lost information from working memory, not building new long-term memories as effectively and therefore not learning as well.

And if we do all that science, then we might be in a position to harness those scientific methods and tools to detect lapses of attention, and we can then ask the question going back out to society, can we scale these up? Is there a meaningful relationship between academic performance and an individual's propensity for whatever reason, whether it is because of media multitasking or not? Is there a relationship between an individual's propensity to suffer from attentional lapses and academic performance in the near term? Over a semester? Over a high school career or middle school sort of career? Over time in college? And if so, can we use these now methods developed from the basic science to detect these moment-to-moment lapses of attention and to help an individual get back to effectively performing and and thriving academically in health, in navigating their careers, et cetera?

Bill Glovin: Well, I think that is a great note to end on. I cannot thank you and Kevin enough for the article, and for you taking the time to do the podcast. Again, the article is called "[The Multi Costs of Multitasking](#)" by Drs. Anthony Wagner and Kevin Madore, and you can find it in the middle of the homepage at [dana.org](#). You will also be able to find this podcast and all our podcasts in transcript form if you'd like to maybe read some of this. Meanwhile, have a great day and thanks for listening.

Anthony Wagner: Thank you, Bill. I very much enjoyed the discussion.