

# **BRAIN SCIENCE PODCAST**

*With Ginger Campbell, MD*

## **Episode #16**

**Discussion of the Book, *The Executive Brain: Frontal Lobes and the Civilized Mind* by Dr. Elkhonon Goldberg**

Aired July 12, 2007

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## **INTRODUCTION**

Hi. I'm Dr. Ginger Campbell, and this is the *Brain Science Podcast* – the podcast for everyone who has a brain. In this podcast we explore how recent discoveries in neuroscience are unraveling the mysteries of how our brains make us who we are.

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Welcome back to the *Brain Science Podcast*. This is Episode 16. Today we are going to be discussing the book, *The Executive Brain: Frontal Lobes and the Civilized Mind*, by Elkhonon Goldberg. But first here are a few announcements. I seem to have finally resolved most of the issues with the podcast feed. So, if you're having any problems getting the feed please let me know.

If you happen to be using iTunes, look and see whether or not you're seeing all the episodes. And if it still shows that the podcast is coming out of Podango, or you're having problems seeing all the episodes, what I recommend that you do is unsubscribe and re-subscribe. If for some reason the feed has disappeared from iTunes and you are getting this episode by coming to the website, what you need

to do is just go ahead and re-subscribe. You can find both of my podcasts in iTunes by searching under Ginger Campbell.

Now for the good news. I have finally launched the Brain Science Podcast Discussion Forum, and you can find that at [brainscienceforum.com](http://brainscienceforum.com). I hope you will go to the website and see what areas interest you, and maybe start some discussion topics. I have put a place in there where there is a link to all the previous comments that have been posted. For those of you who have posted a good comment on the website and might want to reuse it in the forum, all you have to do is follow the link and then you can cut and paste your previous comment. I'm looking forward to seeing what everyone has to say on the forums and giving you all a chance to interact with each other.

In other news, many of you may be aware of the launch of the iPhone. And some of you may have an iPhone and you may have heard that the iPhone doesn't support Flash. However, the audio files that are on my website are basically Quick Time, so if for some reason you have memory constraints and you need to not carry the *Brain Science Podcast* in the podcast section on your iPhone, all you have to do is go to the website and click on the 'Listen to the latest episode' button, or you can go to the Episode page and all the episode links are there.

Finally, I have to apologize for the fact that on my last episode I promised that there would be a new episode of *Books and Ideas* coming out the following week, and that episode has not actually come out yet. It's still in planning. However, I didn't want this episode to be late. If you subscribe to *Books and Ideas* I apologize, and I promise that there will be a new episode out soon.

I will be having an announcement at the end of the show about an exciting interview that will be coming up, not on the next episode of *Books and Ideas* but probably the following one. So, that's enough muttering around. Let's get into today's topic.

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## DISCUSSION

Today we are going to be talking about the role of the frontal lobes, and in particular the role of the prefrontal lobes. For those of you that have been listening to the podcast for awhile you know that in recent episodes we've talked a lot about things that happen at unconscious levels in our brain that we really can't control. And it starts to look sometimes like we don't have any control over what's going on in our brain. But this isn't true. It turns out that it's really in the prefrontal lobes that our personality and our decision making happen.

The first hint that we had that the frontal lobes were important in personality and behavior happened back in 1848 when a famous guy named Phineas Gage, who was a construction worker, had this big railroad spike go through the front of his head. I put a link for this on the website. There are some pretty interesting pictures available of this. But anyway, he actually survived but he had a marked change in his personality. He had been very responsible and he became basically shiftless, and unable to hold a job, and whatever. This kind of behavior has been seen many times since then with frontal lobe lesions, and so this is one of the ways that the importance of the frontal lobes has been appreciated.

However, there hasn't been that much written about the frontal lobes compared to some of the other areas. So, I was looking for a book about the frontal lobes, and I found this book, *The Executive Brain: Frontal Lobes and the Civilized Mind*, by Elkhonon Goldberg. Dr. Goldberg is a neuropsychologist and his background is pretty interesting because he actually escaped from the Soviet Union back in the 1970's. But he studied under a famous scientist, Luria. Anyway, this book is from 2002, and I'm going to talk today about some of the highlights from the book.

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The forward to *The Executive Brain* was written by Oliver Sacks, who is a respected neurologist and best-selling author. The forward gives you a good overview of the book and it also puts Goldberg's work into perspective. He points out that Goldberg was one of the first to challenge the modular model of the mind. Now, I'll explain what I mean by that in a little while. Sacks also refers to Goldberg's fondness for the philosopher, Spinoza.

Spinoza is well known to be one of the first to think about the mind and the body together. And Sacks has a wonderful quote in the forward: "Spinoza had no sense that the human mind, with its noble powers and aspirations, was in any way devalued or reduced by being dependent on the operations of a physical entity, the brain." I like this quote because it sums up how I feel about the subject, too. I don't feel that knowing more about how our brains create the mind diminishes our mind in the least.

So, why do we even care about the frontal lobes? Well, as Dr. Goldberg says in the introduction to his book, the purpose of his book is to explore what he calls the one part of your brain that makes you who you are. And I'm going to show you how it is that this argument can be made that the frontal lobes are what make us human. They're also considered to be what he calls the command post of the brain. Unfortunately our frontal lobes are also particularly fragile and vulnerable, and this has implications for what happens in brain injuries and in aging.

Dr. Goldberg refers to the frontal lobes as the executive lobes. He likens the role of the prefrontal cortex to that of a CEO of a big corporation. You often hear it said that the human brain is the most complex natural system in the known universe, and when we start talking about the frontal lobes we'll see some of the reasons why this claim is made. Now, I may sometimes talk about the frontal

lobes, but what I'm really talking about in this episode is the prefrontal lobes. What I mean by that is the frontal lobe is the whole front lobe of the brain, but the sort of back part of the frontal lobe is where the motor cortex is. That's not the part that I'm talking about. I'm talking about the most front area which is kind of over your eyebrows, and that's the prefrontal lobes.

Some of the things that the prefrontal lobes do that are important are: they have a very central role in forming goals and objectives and then devising plans. Our frontal lobes figure out what we want to do and how we're going to do it. They also evaluate our actions for success or failure. Remember the dopamine feedback system that Dr. Montague talked about in the last episode. This is very much a feedback system that involves connections to the frontal lobes. But of course the prefrontal lobes do much more than this, and we'll only touch on a few of these aspects today.

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Before Dr. Goldberg gets into the frontal lobes in his book he gives some autobiographical information, which I'm not going to talk about. And he also gives a brief introduction to the architecture of the brain—what he calls a primer. I think this is really an excellent introduction to the basic structures of the brain and what they do. Of course, my discussion here will suffer because I do not have the diagrams that he has in the book.

The first important principle to remember is that the brain couples two complex systems, one chemical and the other structural, and this combination increases the system's overall complexity exponentially. The other thing that increases the complexity is the fact that there is a ubiquitous presence of feedback loops. One interesting thing is that most of the structures of our brain are shared with other animals, and these structures are of varying ages from an evolutionary standpoint. For example, the division of the brain into the right and left

hemisphere occurred very early on in evolution and is seen even in primitive animals.

I want to talk about a few of the important so-called subcortical structures. The cortex is the outer part of the brain, so subcortical means the deep structures of the brain. First of all there is the thalamus and the basal ganglia. I'm going to give you ways of thinking of these parts of the brain that are pretty simple, so it doesn't matter that you don't know exactly where they are. The best way to think of the thalamus is that it is a relay station for all the incoming sensory information. The basal ganglia is in charge of basic motor behavior and action.

Then there's the hypothalamus, which is in charge of maintaining internal homeostasis. It controls things like food intake and body temperature. If you put the thalamus and the hypothalamus together they are called the diencephalon. Then there is the amygdala. It's considered part of the basal ganglia but you often hear it discussed separately because it's so critical for survival. And we've already talked about its role in emotion and unconscious decision making.

Another structure that's important, of course, is the cerebellum, which is that sort of little place on the back of your brain that looks different from the rest. It's important for coordination of movements. It's closely connected to the frontal cortex, especially with regards to planning movements.

So, those are parts of the brain that have been around for a long time. The cortex appeared fairly late in evolution. The oldest parts of the cortex are the hippocampus and the cingulate gyrus. Those are actually parts of the brain that we have talked about in previous episodes when talking about memory. Sometimes you'll hear the term, limbic system. It refers to the amygdala, hippocampus, and cingulate gyrus. But lumping these together implies a functional unity that probably doesn't exist, so this term has really fallen out of favor with scientists. I think I did refer to it in my early review of *On Intelligence*.

The limbic system came to fame probably partly as a result of a book written by Carl Sagan back in the 70's called *The Dragons of Eden*. This was the first book to introduce the idea that various parts of the brain had come along in an evolutionary order and that we have parts of our brain that you might say we've inherited from the dinosaurs, and reptiles, and what not. But anyway, limbic system is not a phrase that we'll be using much in the future.

The neocortex was the last part of the brain to evolve. That's the wrinkled part that forms the surface of mammalian brains. The neocortex has a unique columnar organization that makes possible a new level of interconnection between the various parts of the cortex and other brain areas.

This columnar organization is discussed in Jeff Hawkins' book, *On Intelligence*. I didn't have time to talk about it in the podcast, but if you're interested in that I recommend his book. I think two people have already put that book up on the new Discussion Forum, so I think it's easy to say that is a very popular and good book.

The neocortex, the way that it's organized, the front of it seems to be devoted to action and the back to perception. It's also divided up into four main lobes: the occipital lobe which is in the back, which processes visual information; the temporal lobes on the sides process sound; the parietal lobes that process tactile sensation; and then the frontal lobes which are in charge of movements.

Now, one obvious thing that you might think of is the fact that all of these functions that I've just described had to have already been performed by the older parts of the brain. They are still performing these functions in lower animals. This fact has a lot of interesting consequences because it means that there has to be a coordination between what the older parts of the brain want to do for these things, and then the cortical control. And sometimes these actually do come into conflict.

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So, we've got our cortex; the mammals have the neocortex. Then we have the sudden emergence of the large prefrontal cortex, which is considered to be uniquely human. Our prefrontal cortex is estimated to take up about 29% of our cortex, whereas the amount that it takes up in a chimpanzee is only 17%, and in a dog it's only 7%, and in a cat 3½%. These numbers are based on measurements published by Brodmann in 1909, but the basic principle is that the prefrontal cortex is what has grown and made humans different from even our closest relatives.

Now, how is the prefrontal cortex defined? Anatomically it's defined as the part of the frontal cortex that gets projections from what's called the dorsomedial thalamic nucleus. That just means it's getting projections from the thalamus. It also is receiving projections from what's called the mesocortical dopamine system. We don't care particularly about these specifics; it's just that that's how they make the measurements when they're trying to decide how much of a particular brain is prefrontal cortex.

OK, we've done enough anatomy so that we can put the prefrontal cortex into the context of the rest of the brain. So, now we are ready to consider some key ideas about the prefrontal cortex. First, it's probably the best-connected part of the brain. It's connected to virtually every unique functional unit of the brain. It has important two-way connections with the amygdala, the hypothalamus, and the brain stem structures that regulate arousal and activation. And, of course, it's connected to many other parts of the cortex.

These connections are important because they mean that the prefrontal cortex can coordinate the functions of the rest of the brain. That's where the executive lobe idea comes in. Also, the prefrontal cortex has the ability to form a map of the whole cortex because it's getting connections from everywhere else. This is

probably the key to our developing a sense of self. A sense of self becomes important only when you come to the great apes. And as we understand more about this we can begin to appreciate better the similarities and differences between us and our nearest relatives, the chimpanzees and bonobos. So, the bottom line is it's because they also have relatively large prefrontal lobes that the great apes have some of the qualities that we have that no other species have.

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Now, there's one topic that Dr. Goldberg gets into in this book that's important, even though it's not specifically about the frontal lobes. And that has to do with some issues about the asymmetry of the right and left hemispheres, and also the question of whether or not the cortex has a modular function. You've probably heard the old idea that the left hemisphere is mainly devoted to language and the right hemisphere is mainly devoted to spatial and other non-verbal tasks. Well, new evidence is really beginning to challenge this simplistic view. One clue might be that this asymmetry between the cortexes appears long before the emergence of Man, i.e. in lower species.

For example, the right frontal cortex is thicker than the left, and this can be seen even in rats. The structure of the temporal lobes, which are traditionally associated with language, is also asymmetrical in orangutans, gorillas, and chimpanzees. There are also biochemical differences between the hemispheres. Since all these differences appear in non-humans I think it's reasonable to argue that they are not likely to be caused by language.

Dr. Goldberg presents the alternative hypothesis that is that the right hemisphere deals with novelty and that the left hemisphere deals with routines, or pattern recognition. He first published this hypothesis in 1981. One implication is that since learning naturally progresses from novelty to routine it would be expected that such behaviors would gradually shift from the right to the left hemisphere.

This hypothesis fits the belief of another scientist, Nobel prize winning psychologist Herbert Simon, who thinks that learning involves an accumulation of easy to recognize patterns of all kinds.

Linking of novelty to the right hemisphere and cognitive routines to the left hemisphere forces us to look at the brain in a new way. Of course, novelty and routine are relative, and any relationship of this sort must be dynamic. But we have some examples from functional imaging that support this hypothesis. Let's take music, for instance. We've been told that music is processed by the right hemisphere, but it turns out that in trained musicians they use mainly the left hemisphere. Also, with facial recognition it turns out that new faces are processed on the right and familiar faces light up the left.

Findings from functional imaging support this new approach because they consistently show that during learning the right hemisphere is more active, but a familiar task tends to shift over to the left. Hopefully this is providing more accurate information than was traditionally obtained by making assumptions based on what was lost during brain damage.

So, a new version begins to emerge that has cognitive hierarchies in which the first level is the primary sensory and motor projections. At this level things are very modular. Then at the second level we have the cortical areas that are involved in more complex information processing, and this is more of a mixed level. And then at the third level there are the areas of the cortex that appear latest in evolution and do not seem to have any specific modularity. So, you have a situation where when you get brain damage to adjacent parts of the cortex you may get similar but not identical deficits depending on where the damage occurs.

This new theory gives us a view in which cognition is distributed throughout the cortex in a graduated and continuous manner instead of a modular or encapsulated manner. Again, this gives us a new way of looking at the brain, both

in terms of function and dysfunction. The bottom line is that it appears that the older parts of the brain probably are modular but that the neocortex isn't. Consider, for example, how our brain represents an object. Actually the representation of that object is distributed over the cortex.

Now, how would we see this? Well, a person can have brain damage, say from a stroke, in which they can no longer tell what an object is by looking at it, but if they pick it up they can. And visa versa, they may not be able to tell a familiar object just by touch but if they can see it they can tell what it is. And what that tells us is they haven't lost their knowledge of what the object is, they've just lost pieces of its mental representation. So, this really kind of supports that distributed approach.

And there is evidence that language is also distributed. It appears that words that are associated with action seem to be in the frontal lobes and words that are associated with objects seem to be in the parts of the cortex associated with their representations. So, again, the cortical representation of objects seems to be highly distributed.

Interestingly, it turns out that the ability to name living things may be more likely to be lost in brain damage than the ability to name inanimate objects. And this implies that the mental representations of inanimate objects might be more widely distributed. He sums up this idea on page 67 saying, "Like the mental representations of the physical world itself, the mental representations of language denoting the physical world are distributed."

Now, this might seem very surprising, but if you've listened to any of the episodes about memory, especially in Episode 12, we talked about how it turns out that long-term memories appear to be distributed into the places where the sensory and motor sensations originally occurred. So, this is really basically the same idea.

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So, we've talked a little bit about the fact that the frontal lobes are most active when we're in new situations. But the frontal lobes are also important to memory, although for a long time this wasn't very well understood because the way the experiments were designed tended to eliminate the role of the frontal lobes. The experimenter would tell the person what to remember, and what the frontal lobe has to do is decide what information to retrieve. Think about it. Real life acts of memory are about deciding what type of information is useful at the moment. So, the key idea is that the frontal lobes know where stuff is and they decide when it's needed. This selection of what information to use is also a key function of the frontal lobes.

Another thing the frontal lobes have to be able to do is to help us to be constantly shifting between tasks. So, this would essentially be a form of working memory that is keeping in the mind what you need for the task at hand. And problems with working memory appear early in dementia, which goes against the assumption that the frontal lobes were being spared in dementia.

One paradox is that while the frontal lobes are critical for accessing and activating this important information, they do not contain the information. One of the consequences of this is that we can see frontal lobe function being affected by damage to other parts of the brain. Say it sends out a signal to retrieve some information to a part of the brain that's been damaged, then good information is not going to come back

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Now we are ready to consider probably the most important issue, which is about choice and decision making. In studying the role of the frontal lobes it's important to realize that there are two types of decisions: the types that involve

just matters of fact, and those which are adaptive. And most of our real life decisions involve ambiguity, and it's dealing with ambiguity that is one of the foremost frontal lobe functions.

One of the reasons we know this is because of the fact that people with frontal lobe damage do very poorly. I remember the example that I heard from Antonio Damasio of how if he asked a patient, 'When do you want to come for your next appointment?' they would just dither around. But if he gave them a choice like, 'Do you want to come next Tuesday?' they could handle that. One was not an ambiguous question and the other one was.

Dr. Goldberg and one of his students, Ken Podell, developed a test that he called the Cognitive Bias Task, which measures some of the ways that people make decisions. And the way that this test—called CBT for short—works is that the person is shown a target item and they're shown two other items and asked to choose. They're told either, 'Choose whichever one you like,' or, 'Choose the one that's most alike or different.' The 'choose whichever one you like' option represents ambiguity and the 'choose the one that's most similar' is the veridical example. This test is described in more detail on page 81 in the book.

The responses to the test were highly replicable. And what they found was that damage to the frontal lobes changed people's responses but damage to other parts of the brain didn't. If a person had frontal lobe damage and they were asked to pick the target they liked—which would be an ambiguous type situation—they had trouble. If they were asked to pick the target that was most similar to another or most different they did just fine. This is a demonstration of the role of the prefrontal lobes in deciding how to interpret ambiguous situations.

It turns out that adaptive decision making seems to decline early in dementia, and this is something that is often missed because it's been assumed that the frontal lobes were fairly invulnerable. On this subject Dr. Goldberg is, I think,

writing with great authority because in his job as a neuropsychologist he is very much involved in the diagnosis and early diagnosis of dementia. And the point he makes is that these early deficits are often misdiagnosed as depression or something else. And he is hoping that maybe we'll eventually get more sensitive tests so that we'll be able to make better early diagnosis.

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But the thing that was revealed by using this same test with normal people is that people have two major cognitive styles. He calls one of these styles context-dependent, and that is the subjects that tend to match their choices to the target, and so if the target was changed they would change their choices. The people who have the context-independent strategy would keep the same choice no matter whether the target was changed. Their choice didn't really change. There seems to be a tendency for males to be more context-dependent, while females tend to be context-independent. But, of course, like most tests of this type there's overlap. However, he says that the results were very robust and significant.

Now, obviously which strategy is best depends on the situation. Consider a novel situation. In that situation probably the context-independent approach might make a good default strategy because it gives you something to do even when you don't know anything about the situation. It sort of represents an average of all the possible solutions, but it gets you started. So, that's the context-independent. On the other hand, if you are in a familiar situation then the context-dependent strategy—which means matching your solution to the specific properties of the situation—would seem to be most appropriate.

Context-dependent strategy is good for situations where pattern recognition can be used. It's not so great for the completely novel situation. So, obviously optimal decision making would be a dynamic balance between these two

strategies. This approach is also useful for developing computational models using neural nets.

I'm not going to get into a lot of the detail about this, but it turns out that which one of these decision-making styles we have depends on the differences in our frontal lobes. And differences are also seen in decision-making when people have brain damage. One important principle to remember is that the difference in frontal lobes begins before you get to humans. It's seen in non-human species. And if you're interested in learning about the differences between men and women on this subject, he talks about this in a little bit more detail in the book.

Instead, I want to talk a little bit more about the aspects of frontal lobe intelligence: some other important things that our frontal lobes do for us. First of all they give us the capacity for insight into other people's minds. And they also give us the ability to control our output. That is, like say you get the urge to cuss at somebody but you don't do it. It's the frontal lobe that overrules that lower, maybe amygdala thing, to do something.

Also, closely related to the idea of a sense of self is differentiation of self and non-self. Great apes are the only animals besides us that can recognize themselves in a mirror. And you can prove this to yourself. Just pay attention to what happens the next time your cat or dog is near a mirror. They usually, once they're past being a puppy, just ignore it. So, these aspects of the prefrontal cortex are the reason why he says that this is the closest thing we have to the neural substrate of social being.

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Why does all this stuff happen in the prefrontal cortex? It all comes back to the fact that the prefrontal cortex is so interconnected to the rest of the brain. The prefrontal cortex is the only place where the information from the internal

environment merges with the information from the outside world, which means it has to be where these two sources are integrated. Now, we aren't going to have time today to get much into what happens when the frontal lobes are damaged. Obviously they're very vulnerable, partly because of the fact that they represent this convergence of connections from everywhere else.

The more we learn about the importance of the prefrontal lobes, the more it brings up questions in areas such as social maturity, morality, and the law. We know that the frontal lobes are important for social maturity, so now we're beginning to face controversial questions about the role of early childhood experience in these developments. And moral development also seems to depend on the frontal lobes.

So, this brings us to the question of responsibility. When it comes to criminal behavior, because of the role of the frontal lobes in planning it turns out most people with damaged frontal lobes don't become criminals. They become socially incompetent but they really don't often become criminals. And when they do they're usually not very good; they're not criminal masterminds. The situation of the brilliant psychopath is really going to be pretty rare, if not almost impossible.

But you have the ironic situation where you could have direct frontal lobe damage causing very little dysfunction, while damage downstream might cause severe dysfunction. Now, why does this matter? Well, it means that you can't just do an MRI or scan of somebody's brain and say, 'Oh, well they have frontal lobe dysfunction, so now they're off the hook.' It's just not that simple.

One of the key questions, I think, is what is the responsibility of a person who knows an act is wrong but can't stop himself, compared to one that has no sense of right or wrong? Both of those types of problems could come up, depending on where the damage was. So, what are the implications of taking these biological factors into account in legal matters? Goldberg asks if we should, "...acknowledge

that whereas moral and criminal codes are extracranial, moral and criminal cognition and behavior are not?”

So, it brings up some pretty sticky issues that I know people in the legal field are dealing with. I guess I come to it from a sort of a single standpoint of feeling that it's likely that there's a certain breed of lawyers who will be getting people off for stuff that they really should not get off for. From the other standpoint Dr. Goldberg points out that people with brain damage are often not accorded the same level of sympathy and support that people are that have physical ailments.

Consider the fact that most insurance doesn't pay the same for mental illness. And that's really out of step with the growing knowledge that these problems are physical or brain-based. He calls this naïve dualism, since there still seems to be an attitude that these mental problems are somehow different. And I think it's true that many people are uncomfortable with facing the fact that the brain might be the seat of something like moral behavior, since we've long been told that this is not coming from our brain but coming from someplace else like the soul.

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He also—and I apologize because I don't have time to get into these in great detail—talks about some other problems such as schizophrenia and ADHD. Both of these seem to be diseases that involve the frontal lobes. The bottom line is that when these conditions are treated with drugs that influence some of the neurotransmitters, they are not getting at the basic problem.

For example, in schizophrenia people usually think of the psychotic symptoms of schizophrenia: hallucinations and what not. But the frontal lobe systems are more of a negative kind of depression, lack of ability to make decisions and plan, and that sort of thing; more cognitive deficits. These are not at all improved by the drugs that are used to stop the hallucinations. And when you have a model of

a disease like schizophrenia and you say schizophrenia is a dopamine disease, then that limits the ability to find the solutions that are really going to help people because it's ignoring some of the basic mechanisms.

This may also be part of the problem with the treatment for ADHD, which he notes really is a true frontal lobe dysfunction. But he points out on the subject of ADHD, "Very few lay individuals would presume to make the self-diagnosis of pancreatitis, but most people would have not compunction self-diagnosing their ADHD." And I think that's one of the problems with ADHD. It is real, but then it's so over-diagnosed without use of real tools.

So, the bottom line on this particular area is that drugs are of limited effectiveness in treating these various diseases because they don't really get to the root of the problem at this point. And because they use blocking neurotransmitters or simulating neurotransmitter receptors they tend to cause other symptoms. However, since a lot of these problems seem to involve dopamine receptors there is some hope that maybe once they get the specific dopamine receptors isolated they might at least be able to develop more targeted drugs.

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Now, there's a topic that he alludes to at the end of the book which I find so interesting that I'm going to talk about it in detail next time, and that is the question of age-related mental decline. It turns out that aging does not inevitably mean mental decline. One of the famous cases is the nuns of Notre Dame, one of whom was autopsied and found to have severe signs of Alzheimer's disease. But she didn't really have any signs of it in life; she was an extremely mentally active person. So, this seems to indicate that education and mental activity are protective.

This shouldn't surprise us because we've been talking about neuroplasticity in recent episodes. It gives us the idea that maybe cognitive enhancement could actually change brain function. I think this is a really interesting idea, but we have to be on the lookout for people that are going to be selling products that are scams because there is also evidence that when you learn a new skill, that is highly specific and it's not necessarily generalizing. So, while you might learn a specific thing and it generates some growth in a certain part of your brain, it's not like that necessarily makes all of your brain better.

I have had some email correspondence with Dr. Goldberg, and I'm hoping to interview him in a couple weeks. And when I do I'm going to talk to him specifically about his work with trying to develop exercises to help people, both to regain brain function and do protective type stuff.

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What we close with is a picture that tells us that our brain is massively interconnected. The neocortex is connected to every other part of the brain. At the lower levels like the thalamus there are specific nuclei that suggest a modular approach, but the cortex itself does not have distinct borders. So, these two structures—one representing a very old part of the brain, and one representing a very new part of the brain—are at different levels of organization and complexity.

I've just barely touched on the importance of the prefrontal lobes, but I hope that you can begin to see that the prefrontal lobes are the part of our brain that makes us truly unique, both as people and as individual people. They are the part of our brain that takes everything from both the external world and our internal signals, puts it together, makes plans, and decides how we're going to live our lives. Obviously this is a subject that we are going to need to talk about more in the future. And I'm sure that there are going to be more and more discoveries on this

subject, and some of them will probably bring surprises and changes in this information.

I am going to continue the discussion of the prefrontal lobes in the next episode. In fact, I'm going to do something that I have really not done before, which is to follow up with a discussion of a second book by the same author. In the next episode we're going to be talking about Dr. Goldberg's more recent book, *The Wisdom Paradox: How Your Mind Can Grow Stronger As Your Brain Grows Older*. We'll learn some more about the prefrontal lobes, and also more about the right-to-left shift that we talked about in this episode. We will explore the question of what is wisdom from the standpoint of brain function. I hope that you will join me for that episode, which will be coming out in a couple of weeks.

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Before I get into the closing announcements for this episode I had to insert this little piece. I need to mention that I am hoping to get some sponsorship from Audible.com. Audible.com says that they have over 35,000 audiobooks available for download, and I'm sure this is true. I've been downloading all my audiobooks from them since 2003. Anyway, what I expect to happen is that they're going to give me a one-month trial during which they're going to pay me a small flat rate, but they're going to keep track of how many people come to visit them from my sites [brainsciencepodcast.com](http://brainsciencepodcast.com) or [booksandideas.com](http://booksandideas.com).

The complicated part is that it's not supposed to go into effect until July 16<sup>th</sup>, which is why I don't have any official ads in this episode yet. This means that I have to ask you to visit [brainsciencepodcast.com](http://brainsciencepodcast.com) on or after July 16<sup>th</sup> and then click on the ad. That is, of course, if you're interested in downloading audiobooks. For example, the book, *On Intelligence*, which I have mentioned in the past and was mentioned in this episode, is available at Audible.com.

Now, I don't have the final details yet but the way that this has been working for other podcasts is that when you click on the ad for the particular podcast or the address that they give you, then you go to Audible.com and you get the offer for a free audiobook if you sign up, with no further obligation. I don't know this for sure yet but I would assume this is the way that this is going to work.

Anyway, I just wanted you to understand that the only way that I can make any ongoing funds from this sponsorship is that if you actually click on the ad. Now, if you're not interested in audiobooks, just forget it. But just understand that if you just go to Audible.com on your own separately I don't get any credit for that. Anyway, I'd appreciate your thinking about going to my site if you're interested in downloading audiobooks.

[music]

Well, as usual, my podcast came out longer than I had intended it to. I hope that you found the information on the prefrontal lobes interesting. And I, for one, am looking forward to learning more about this topic in the future. I want to remind you to visit the new Brain Science Podcast Discussion Forum, which is located at [brainscienceforum.com](http://brainscienceforum.com). Also, you can visit my website at [brainsciencepodcast.com](http://brainsciencepodcast.com) or send me email at [docartemis@gmail.com](mailto:docartemis@gmail.com). If you aren't already subscribed to the podcast, go to the website at [brainsciencepodcast.com](http://brainsciencepodcast.com) and you will see the subscription options there, which include email subscriptions, iTunes, and RSS feeds.

Also, be on the lookout for the next episode of *Books and Ideas* which is going to be on the issue of free will, which I think is highly relevant to what we've been talking about. I hope to get that out next week. And, as I mentioned, I am going to be interviewing Dr. Elkhonon Goldberg for *Books and Ideas*. But that episode will probably be posted after the next episode of the *Brain Science Podcast*.

As always, I really appreciate your feedback. I hope that you will participate in the forum or send me email at [docartemis@gmail.com](mailto:docartemis@gmail.com). Thanks again for listening. I'll talk to you soon.

[music]

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