

BRAIN SCIENCE PODCAST

With Ginger Campbell, MD

Episode #37

Interview with John Medina, PhD, author of *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School*

Aired May 16, 2008

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INTRODUCTION

This is the *Brain Science Podcast* – the podcast for everyone who has a brain – and I’m your host, Dr. Ginger Campbell. On the *Brain Science Podcast* we explore how recent discoveries in neuroscience are unraveling the mysteries of how our brains make us who we are. For more information including Show Notes, links to previous episodes, and information about how to subscribe please go to the website brainsciencepodcast.com. We also have a Discussion Forum at brainscienceforum.com, and you can send me email at docartemis@gmail.com.

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Welcome back to the *Brain Science Podcast*. This is Episode 37. I think this is going to be a very good episode for new listeners and an episode that regular listeners will enjoy sharing with friends and family. It is an interview with John Medina, author of the book, *Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School*. John is a developmental molecular biologist and a research consultant, and he works at Seattle Pacific University and also teaches at the University of Washington School of Medicine in its Department of Bioengineering. His book is aimed at showing how what we have learned from research into the brain can be used in a practical way.

As usual I'm going to try to get right into the interview and save all my announcements for the end. I do want to mention one thing, and that is that for the next several episodes I'm probably going to keep reminding you to do the audience survey. There are links to the survey on both my website and at the Discussion Forum, but if you want the link directly it is wizzard.tv/survey/brainsciencepodcast. I appreciate your doing this because it helps me to provide information to potential advertisers. It's also useful when potential guests ask me about who is listening to the podcast.

Now, let's just get right into the interview.

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INTERVIEW

GC: I'm really happy to have John Medina on the *Brain Science Podcast* today. Thanks for coming on, John.

JM: Hello. I'm glad to be here, Ginger.

GC: Could you start out by just telling us a little bit about yourself?

JM: I'm a developmental molecular biologist by training, and I've spent a long time looking at the distance between a gene and a behavior. I've had a special interest in the genetics of psychiatric disorders. I love the window that it gives you if you really are interested in how the molecules of the mind interact with the mind and allow behaviors to occur. And so, I've been a private consultant, primarily to the pharmaceutical and biotech industries, on issues related to mental health.

GC: The question I had in my mind to ask you was how does one go from being a molecular biologist to being a brain scientist?

JM: Well, if you are interested in behavior, and you're interested in human behavior, there's no place like the brain. One of the things I have a strong interest in is trying to understand how at the level of cell and gene a brain gets knit into the womb, and then what happens when things screw up and you get a psychiatric disorder to occur. So, I've had the great privilege of working on a large number of projects—ranging from depression, to Alzheimer's disease, to schizophrenia, to Down syndrome—a whole range of issues that are related to mental health and the genetics of behavior.

If you do that stuff for a living, after awhile you have to get a good strong sense of what it is like for typical human brains to process typical information, if you want to look at it when things go aberrantly. So, I started getting interested a lot in just how brains learn normally. And as I was going down that road, Ginger, I began to notice very quickly that there were a lot of mythologies that I began reading about, about what human brains could do. And I panicked. You would hear things like only 10% of the brain is utilized at any one time for information processing, that there's such a thing as a left brain/right brain personality, Mozart effects, all these things.

And I would think, man, what literature are people reading about that I don't know? And then I would get angry, because there is no literature for that kind of stuff. And I thought there's so much misinformation about how the brain actually processes information that I thought I'd write a book about it and give 12 things we do know from the research literature that are very solid about how the brain works.

GC: In a way we're kind of doing the same thing from different angles, because my motivation for doing the *Brain Science Podcast* is to get accurate information out about neuroscience, because there's so much stuff in the mainstream media that just tends to get so distorted or simplified. I think there was even a post about this in *The Huffington Post* yesterday. Somebody was complaining about

ABC completely misrepresenting some study that made it sound like the brain was hard-wired, when that wasn't even what the study was about.

JM: Well, in the book, *Brain Rules*, I tried to put a more positive spin on it by doing it this way. I tried to give it a positive framework—a thought experiment. I wondered, if you reengineered a learning environment to take advantage of the brain's performance envelope, if you really wanted to redesign an education system or a business along the lines of how a brain actually works, what would that look like?

And I begin the premise by addressing the mythology directly. We actually don't know very much about how the brain works, in my opinion. I mean if we ever knew how to pick up a glass of water and drink it, it would represent a major achievement. But we know something about its performance envelope. In fact, that's fairly easy to understand. The brain appears to have been designed to solve problems related to surviving in an unstable outdoor setting, and to do so in near constant motion. Well, that envelope gave me an idea, and eventually the book, *Brain Rules*.

Because it occurred to me, if you really wanted to create a learning environment that was directly opposed to what the brain was good at doing and you left the mythologies out of the equation, if you wanted to do something directly opposed, you'd probably design something like a traditional American classroom. And if you wanted to create a business environment that was directly opposed to what the brain was good at doing you'd probably design something like a cubicle. And if you really wanted to re-engineer learning environments to take advantage of our more modern understanding of how the brain actually works you're going to have to tear down a few things and start over. So, in many ways *Brain Rules*, starting over is what that book is all about.

GC: So, if you could accomplish one thing with this book it would be to get somebody to start thinking about changing the way we do these things?

JM: Well, yes. And in a practical setting. For example, the brain processes meaning before it processes details. So, if I really wanted to write a book about demythologizing, I would like to give some meaning to the place. Well, if you begin as a thought experiment and you tear down the whole thing—let's focus on schools for a second and start over—what are the things that you would do?

Well, the first brain rule right out of the book is exercise boosts brain power. In fact, exercise improves cognitive performance. You can take a bunch of sedentary 27-year-olds, who eat nachos, would IV a Big Mac if they could, and play X-Boxes all day long, and exercise them with full 100% compliance for four months with an aerobic exercise, and you could watch something—their executive function, which as you know is a measure of their ability to solve problems and to regulate certain impulses—you could watch that very valuable cognitive feature improve anywhere between 80% to 120%.

Then you can do a really dirty trick. You can subtract the exercise and let those guys go back to their own nasty habits, and watch, even within a week, their cognitive scores begin to plummet down to their pre-exercise levels. So, you can turn off certain types of cognition like a light switch, just with the presence or absence of exercise.

GC: Yes. I had John Ratey on the show a few weeks ago. I don't know if you've seen his book.

JM: Oh, I know John well.

GC: Yes, it was a great interview, and I'm hoping to get him back on so he can tell me more about attention deficit disorder, since I know he's an expert on that. So, that's one reason why in our conversation today we won't talk as much about

exercise as we might. But I'm glad you brought it up because I agree with you. And that's one that everybody in their life can apply. We don't have to wait for the world to change, we can change our own personal habits.

JM: Well, if you were to tear it down and start over again another thing that would be a habit that you could break down is this: we know that with declarative information—declarative information is the type of learning that says, 'Thomas Jefferson was the third president of the United States'—you can hold about 7 pieces of declarative information in your head for about 30 seconds. If you don't repeat it, all of that information goes away.

If you do repeat it, it can go into another buffer, which we sometimes refer to as working memory, and there it will hold stable for anywhere between 90 to 120 minutes. If you don't repeat it then, then the information is once again lost and you're never going to get it back. But if you do repeat it you can recruit it for long-term storage. So, you've got a 30-second gauntlet and you've got a 120-minute gauntlet you have to figure out.

If you look at our education system and you see a typical high school might have five 1-hour periods of unrepeated firehose declarative information being sprayed all over the cortex of these students. You can ask the question, is there anything that's repeated in 30-second and 120-minute cycles? The answer is, nope, there's not. But if you were to tear it down and start it all over again you probably would break up those 50-minute periods into, say, well maybe several 15-minute segments, and then repeat the information in an interleaving fashion all day long. My guess is you would obviate the need for homework if you followed a model like that. And in the Brain Center that I direct here, those are some studies we're actually doing.

GC: That's a good segue into the next subject. I wanted to talk about some of your specific brain rules. One of the things I like about your book is you talk

about the importance of experimental data vs. just speculating on how the brain works.

JM: Yes, well I think of that—if we stay with the education theme for a second—I compare how we treat a drug or medication that’s experimental with how we treat an experimental program. The equivalent would be if we treated drugs like we treat experimental programs we’d say, ‘Here’s this nice shiny pill. Isn’t it a pretty pill? We think it works. We actually don’t know if it works. We actually don’t even know what it really does. But you know, we’d like you to try it.’

You can see this with math a lot. ‘Here. Here’s this tasty math program. We don’t know if it works. We’ve never tested it. But by golly we like it, and somebody down the hall said that they really liked it too, so let’s spend a million dollars and deploy it all over a school district.’ We would never do that with medications, Ginger. And I would argue that education is at least as important as the pharmaceutical industry.

So, yes, I’m all over it being empirical. I’m all over it for testing things before we decide that they actually work. And I’m all over it for using the brain’s information processing features as the experimental framework upon which to hang those studies.

GC: And I think it would be fair to say that you believe that we can use what we’re learning about the brain to make people’s lives better.

JM: I think so. I think if given enough time. Education scientists and brain scientists don’t get together very often. But if they did, they would come up with all kinds of things to make our lives better. Here’s a real good example. One of the brain rules is sleep: it’s sleep is as important to the learning process as awake states are. That’s the rule.

We know that at about 2:00 or 3:00 in the afternoon you need to take a nap. And you can actually calculate it. It's 12 hours past the midpoint of the previous night's sleep, is when you need to take a nap. So, if you went to bed at midnight last night, got up at 6:00 in the morning, the midpoint of that night's sleep is 3:00 a.m.—wind it to 12 hours later, that's 3:00 p.m., boom, there's your nap zone. You've probably felt the afternoon sleepies, Ginger, where you need to take a nap at about 3:00.

You can show that if you do take a nap you can get a 20% to 30% boost in cognitive performance. This was actually done with NASA. And if you allow that nap to go about 40 minutes you can have that cognitive boost last for about 6 hours. Now, do you have a room in your office, and do education facilities or businesses have nap rooms where their people can normally take a nap? The answer is, nope, they don't. But if you were to take brain science seriously you'd probably be doing something like that.

GC: Now, why don't we talk a little bit more about sleep, since you brought it up. Do you want to tell us a little bit about what we know about what happens in our brains while we're sleeping?

JM: Yes, I'll be happy to. It's called the opponent process theory, and there are two forces that are locked in a—I'll call it a death match—in your life. You're an electrical engineer, so you would know what a flip-flop switch is. These two things are going back and forth, back and forth. One we call the homeostatic sleep drive. This is the drive to put you to sleep, and the sum total of tissues and molecular forces in your body wants to put you to sleep. And it's at war all day and all night with your other drive, which we call the circadian arousal system. The circadian arousal system is the one that wants to keep you awake all the time. If you deregulate those you can begin to accumulate a sleep debt, because they're supposed to be held in a fine balance.

Now, what's interesting about sleep schedules is that everybody's sleep schedule is different from everybody else's. And after all these years we still don't know how many hours you need to sleep. We do know when you need to get the sleep, though. For example, about 20% of the population are what we call early chronotypes, or larks. A lark typically wants to get up at about 6:00 in the morning and a lark typically wants to go to bed at about 9:00 to 9:30 at night. They report their best times in the morning, and they are morning people. And that's about 20% of the population.

The other 20% are what we call late chronotypes, or owls. These are people that don't want to go to bed much before 3:00 in the morning and don't want to wake up much before noon. And they report that their best, most productive times are in the evening and at night. Now, those sleep cycles with the homeostatic sleep drive and the circadian arousal system are probably set near birth. You can certainly see them at five or six years of age.

I feel badly for the 20% of the population that are late chronotypes. I think they perform very poorly in our society. When they're students going through school they accumulate a massive sleep debt. And their teachers will tell them that they are unmotivated, won't focus, tend not to have any energy, don't care, all kinds of things, when in fact they're carrying a massive sleep debt.

If you could rearrange schools and businesses to take advantage of what we know about sleep, what if you did this? Because there are certainly teachers that are late chronotypes also, why not put the late chronotype teachers with the late chronotype students and keep the school up till 3:00 in the morning where everybody can display their best cognitive performance? Lord knows the building is empty. Wouldn't we do something like that? Well, that's sort of what I mean by tearing down and then starting up again. And sleep is very much a part of those ideas.

GC: Yes, when I read that chapter in your book the first thing I thought about was, I have a very crazy work schedule because I work in a small emergency room, and so I work a 24-hour shift. And actually that might sound like a stupid thing to do, but one reason I do it is because my sleep cycle is less disrupted working that way than if I had to go back and forth between working night shift and working day shift.

But what I've been doing since I read your book is I've been trying to look for a place to sneak in that little nap in the afternoon, which is a time when I would have normally been reading or something and I wouldn't have even considered trying to take a nap. I haven't actually gotten a successful nap yet, but I knew as soon as I read that that it was true, because when I've had that irresistible urge to take a nap in the afternoon and actually been able to do it, I have noticed then I could work till about 3:00 in the morning before I started to feel tired again. But maybe you could give some practical suggestions for people who have more normal jobs.

JM: One of the things that I suggest that people do right off the bat is if they try and figure out what chronotype they are. The vast majority of people are what we call humming birds, and they function fairly well in this society and they can work a 9 to 5 job. But there are people that can't. And so, I tell most everybody the most practical thing you can do is to keep a sleep diary and figure out—if you can; especially if you've got a two-week vacation—when your most natural time is to take a nap, when your most natural time is to go to bed and to wake up. And I also tell them to do that if they have kids. There are increasingly a number of people that are home schooling their children, and so they have the option of being able to have more fidelity with their kid's sleep schedule.

And I tell them very seriously, if you're up even 24 hours a day, Ginger, at those last several hours your cognition is not doing very well. Your memory is not great, your executive function is moving off line, your ability to tolerate stressful

situations and not snap at somebody is beginning to deteriorate. By the end of that time there's nothing good.

And what's interesting about it, when you put folks like that in the laboratory and keep them up 24 to 48 hours and you tell them, 'OK, you've been up for 24 hours, I'm going to give you a calculus test in a minute. I want you to predict how well you're going to do,' every one of them says, "I am going to do just fine.' And maybe they'd do 90% on a calculus test. Typical score after being up for that length of time: about 20%. They have a catastrophic loss in executive function, even though they don't feel it. So, it's very important to pay as close attention to your sleep schedule as you can.

GC: Fortunately usually when I am working my 24 it's rare that I actually have to stay awake the whole 24. So, I think if I did – I mean I can tell – Well, I'm sure it happens before I can tell. I'm sure you're right about that.

JM: Well, we do have to live in the real world there, Ginger.

GC: Yes. I can remember when we were in training there would be times in the night when it felt like it took two people to do the thinking of one.

JM: Well, because I teach in a medical school I go around and around with some of my colleagues about what residency training should look like, and what kinds of conditions you're going to employ if you want to maximize the learning events on the part of the residents. And I know medical emergencies don't have a time schedule. But it is possible to create a dovetailed interleaving menu, if you will, that would allow your late chronotype residents to function at night, and your early chronotype residents to function during the morning, and the hummingbirds—the middle chronotypes—to function during the middle part, and maximize each student's performance.

GC: And the quality of care the patients got.

JM: Well, yes. And the risk for malpractice is going to change. I mean there are all kinds of good things that could happen if we decided to pay attention to our sleep. What blows me away—especially in the medical community—is that we all know better. This is a biology that is open to us if we pay attention to it. The fact that we don't pay attention to it is extraordinary. And it's actually one of the mythologies, probably in its most insidious form: 'Yeah, I can stay up for 48 hours in a row and still be competent for the last 24 of those.' Forget it. You can't.

[music]

GC: We'll be right back after a short break.

[music]

GC: You have 12 brain rules in your book and they're all really good. Some of them kind of overlap things that we have talked about before on the *Brain Science Podcast*, so I tried to pick the ones that I thought would be useful to people. You've talked about sleep, which is obviously very important. Another brain rule that you talked about that I'd like you to talk about with us is your rule #4, we don't pay attention to boring things.

JM: Yes. The brain processes meaning before it processes details. And this is aimed at people that have to give presentations and lectures, or that are just interested in what brains process if you are, say, in business. You can ask the question what does meaning mean, what does the brain pay attention to? And it falls on strict Darwinian lines. It means three things.

The brain is extraordinarily interested in—and I usually couch them as questions:

1. Can I eat it? Will it eat me? We are extraordinarily interested in energy resources, and we are deeply interested in threat. If we think we see an energy resource—if we're hungry—or we think we see a threat, even if we're not

threatened, the brain engages all kinds of systems and we pay deep attention to it. We'll even orient our heads to move in the direction of a moving stimulus. A moving stimulus is a potential threat to us, so we pay a lot of attention to it. That's number 1.

The number 2 thing we pay attention to, what meaning is: Can I mate with it? Will it mate with me? We pay tons of attention to reproductive opportunity. It's not so that we can pay attention to sex: sex is the conduit through which we pass on our genes. That's the goal of the brain, because the brain is the world's chief survival organ. Now, Madison Avenue has this figured out in spades. In fact, I was watching a television show last night and I just saw sex and death for advertisements for television shows, sex and death, sex and death, over and over and over again. All in an attempt to clamor to get my attention to keep me from surfing the channels and to stay on it.

The third definition of meaning, what the brain pays attention to, I think is the most interesting, because there's no a priori for it but it is just as valuable and just as robust as the other two. And that is: Have I seen it before? We are terrific pattern-matchers and the brain is constantly looking for patterns and repetitions of patterns. And if it thinks it's seen one it'll pay attention to it.

It's another thing that I think Madison Avenue has figured out because they'll display this commercial, and you can actually show that if somebody is walking up and down a grocery aisle and they remember a commercial and their eyes light on a particular product, simply the pattern recognition of, 'Oh, I saw that before,' makes you pay more attention to it and you become more likely to buy it. So, we don't pay attention to boring things. What do we pay attention to that makes us non-bored? Death, food, sex, and patterns.

GC: And so, because we're constantly predicting patterns we immediately recognize when something is different.

JM: Yes, we do. We pay attention to novel stimuli. But the novel stimuli in this particular case is always being investigated as a potential threat, energy resource, sexual partner, or a pattern-matching. So, it actually falls into those categories. What I've often talked to college professors and lecturers about is they will often give a 45- or a 50-minute lecture and they never ever give the meaning. They only give the details. And what I've talked to them about is there are studies that show that you can win or lose a student's entire lecture potential for paying attention in about 10 minutes. If you don't pay attention to something in about 10 minutes you've lost them.

And I've won a couple of national teaching awards. I'm a consultant by training, but I do teach occasionally. The reason why I won the awards was real simple. At the 10-minute mark I inserted what I call an emotionally competent stimulus which was related. For example, if I am talking about neurotransmitter release—say, glutamate neurotransmitter release—I will talk specifically about a stroke patient who might have had some motor deficit, and if I make it particularly interesting, then I can hold their attention.

For example, I will sometimes talk about visual processing as a lecture. And I'll start out by simply saying there is an area of the brain that is responsible for processing motion and you can get a stroke in that area. And this one particular patient got a stroke in the particular area that processed motion, and she no longer can see motion. She can see everything else just fine, but if she walks out into the street she has to be very careful because she cannot see that a car is coming at her. The only things she can see are successively large strobe-like pictures of that car, and she'll get hit by it if she's not careful.

So, most students find that interesting, because there's death in there. That's an emotionally competent stimulus. And now I can hold them for about nine or ten minutes and can talk to them about some aspect of Brodmann area 17, or whatever it is the lecture has called for.

GC: I ought to get you to listen to my podcast and you can tell me where I'm falling down on that rule. The thing about this chapter that really hit home for me was the issue of multitasking.

JM: Yes, the brain is incapable of multitasking in what we call the attentional spotlight. Now, you sort of have to be careful with that chapter and make sure that it's read closely, because at one level the brain actually does multitask. The brain is supervising your heart rate at the same time it's talking to me on this interview. You can walk and chew gum at the same time. A piano player could have the left hand doing something and the right hand doing something else simultaneously, and as such it appears to multitask. When it comes, though, to the attentional spotlight for like the things that matter in this podcast, because you want to hold your listener's attention—and a commercial, a television show, a movie, and a lecturer are all wanting to hold their audience's attention—that attentional spotlight is a very particular series of systems in the brain, and that cannot multitask.

There is an area of the brain called Brodmann area 10, which is in the frontal lobe, and you have to consult it every time you want to change tasks. So, if you're busy emailing somebody and you pick up the phone, your brain literally has to stop the emailing and go and consult Brodmann area 10 and ask permission to switch tasks, then switch tasks by permission, find the neural substrates that will allow you to answer the phone, then pick up the phone and answer it. You've just burned 700 milliseconds. Now, when you're done with the phone you've got to put the phone down, go back to Brodmann area 10, get permission to change and find tasks and go back to your email. You've burned through another 700 milliseconds.

So, 1.4 seconds of loss has occurred every time you switch. If you try to do that when you're studying or doing a task you can show that if you have a broken model that's interrupted anywhere between 30 seconds and 5 minutes, that

interrupted model you will make 50% more errors and it will take you twice as long. If you have an uninterrupted model you make 50% fewer errors and it doesn't take you as long.

Where this really shows up is on cell phones. People that are talking on the cell phone while they are driving are a hazard on the road. And the reason is because of Brodmann area 10 in the frontal cortex. You can show that people, that for their mean reaction times on a whole variety of cognitive tests they have all of the performance if they are talking on the cell phone while they're driving—and they're not inebriated, they're not drunk—they will have the mean reaction times and the cognitive performance of someone with a blood alcohol content of .08; and in some cases .12. So, you have to be very, very careful with the fact that the brain cannot multitask, and it's not a good idea to have 17 windows open on your computer at the same time and try to do 2 tasks at once. Your brain is just not very good at doing it.

GC: Yes. What I thought about when I read this was not the cell phone thing—although that does explain why hands-free doesn't have any affect on the amount of accidents.

JM: Right. Right.

GC: I was thinking about how, if I'm working on my podcast, if I sit down and I've decided I have to edit and I'm focused on that and I do just that, I get it done. But if I sit down and I think I've got lots of time and I start answering email from listeners, and going to my website, and doing this and doing that, hours will go by and I have gotten nothing done. And I realize that you just explained why.

JM: Oh, yes. Well, you know in terms of driving, the reason why hands-free doesn't work, the independent variable that predicts the distraction is—I'll call it virtualizing. If you're talking with somebody on the phone you are trying to

imagine what they sound like, what their affect is, what potential content is occurring, and you begin to virtualize the conversation. It's the same kind of thing by metaphor that people do when they read a book. When you read a book of course you conjure up the world that you're living in. Nobody just sits there and reads a book and not have their brain engaged. That's the distracting event. That's the thing. And music doesn't normally play a part unless it's a very interesting piece of music. And that's why you can also be talking to somebody right next to you and you won't be nearly as distracted as if you were on the phone.

GC: So, I guess that also has implications for those of us who like to listen to audiobooks while we drive. I have missed my exit on the way to work a few times.

JM: Well, don't drive drunk with an alcohol level of .08, whether that's because of booze or because of your phone.

GC: Are there any other practical suggestions you would make, or important things you think we should know that relate to how our attention works?

JM: Yes, well I think that one of the largest things to understand about the attentional states is the role that emotions play in our navigating our environment. We actually don't know what an emotion is. And in fact I consider it an artificial distinction between emotion and cognition. They're simply patterns of depolarizing neurons in the brain that are grouped together to do a specific function. But one of the functions that emotions do has to do with the relatively slow computational speed of the brain.

Given all the sensory information that it is constantly flooded with, it is very difficult for the brain to process all of it. And in fact the brain cannot process all of it. The brain instead has to make decisions about what it's going to pay

attention to and what it's not going to pay attention to. And it uses emotions sort of like Post-It notes to be able to say, 'OK, I'm going to attend to this thing but I'm not going to attend to this thing; and I am going to attend to this thing, and not this thing.'

People that have a hard time making distinctions in filtering out the systems often present a lot like a mental disorder. In fact, we can say that, 'You know, there's something wrong with you,' because they'll be talking to you and then all of a sudden they start singing and then say, 'Oh, look, isn't that a nice light bulb,' and so on. And pretty soon you're in psychiatric land—or what would appear to be. It's simply because the emotional regulation is not fully available to them.

So, in terms of being able to pay attention, one of the things that's interesting is to really understand the deep need for us to have emotions and the deep survival benefit that comes from being able to process meaning of something before the detail of something. And I think I could leave it at that.

GC: John, can we talk some more about vision? I've been wanting to do a show on vision and I've had a hard time finding a book that's really at the right level. So, could you tell us just maybe briefly about how vision works? Now, I said briefly. Just a sort of little introduction—and if you want to come back and give us a whole podcast on vision later that would be OK too—since you mentioned that you lecture on that subject.

JM: OK. Well I do, yes. Well you could divide vision into four overall steps, even though it is an extraordinarily difficult and powerful set of brain processes. The brain rule is this: we are primarily visual learners. About anywhere between one-third and one-half of the brain is devoted to pure visual processing. So, it is an extraordinarily important survival feature in our brains. You can divide the visual processing system into four parts.

First of all a stimulus is received and transduced. And by that I mean you organize externally supplied patterns of photons: light gets into your eyes and hits the retina. And the retina is stimulated and fires off a signal to the middle of the brain. It's an area of the brain we call the lateral geniculate nucleus—you can sort of think of it as an air traffic control tower—and it's going to process and push information to the very back of the brain. That's the third step. Those signals get routed to the back of the brain—an area we call the occipital lobe—and particularly to Brodmann area 17, sometimes called V1.

And it is there, once it arrives at the occipital lobe in the back of the brain, that visual processing really begins to take its hold and you begin to parse things out. For example, the brain when it's getting a piece of information in, in step number three, is parsing it out to areas that respond to specific features in the visual stream. For example, there's an area that responds only to diagonal lines; it doesn't respond to straight lines or curved lines, only diagonal lines. There's an area of the brain that only responds to certain colors. There's an area of the brain that only responds to a face. There's an area of the brain that responds to words. You can sort of think of the brain a lot like you might think of a food processor. Information comes in and it gets whirled around and spattered to the back of the brain.

Step number four is the signal, after it's been processed, eventually arrives at what we call the association cortices, and these are involved in higher processing features. Perception has yet to occur, by the way. Step number one is the signal is transduced; number two it goes to the middle of the brain; number three it arrives in the back of the brain; number four, it's just now at number four beginning to create a perception. And your brain literally—we call these top-down features, or sometimes higher processing features of sensory perception—your brain will literally make a judgment about what it sees, and starts to edit it in such fashion that it begins to perceive things.

I usually will tell students, ‘Your brain is not interested in reality, it’s interested in survival.’ And so, your brain will do lots of editing. For example, the signal will arrive in your brain upside down and backwards. Your brain rights it up and puts it straight. And your visual signal arrives in the brain with a big hole in it. We call it the blind spot. It’s an area in the eye—actually in the retina—where the various neurons gather together to form the optic nerve. And at that spot there’s no visual processing. So, it’s a big hole. Your brain fills in that hole. Your brain will even make an edit about what it thinks should be there, given prior experience. And only then, after you’ve done all of that work in step number four, will your brain allow you to perceive something. So, there in a nutshell, that’s how you see.

GC: I think that you put it best in your book when you said we see with our brain, not with our eyes.

JM: That’s right. And there’s a very interesting and dirty cognitive trick you can pull. You can have a video with a bunch of people in a circle and they’re all throwing a basketball, and you can ask viewers to count the number of times somebody catches the basketball. And you can flip those back and forth, back and forth. And then, right in the middle a person in a gorilla suit will walk by. Now, they don’t stay there for very long, but it’s certainly long enough to see the person in the gorilla suit. And they walk by. But if your brain is attending to the basketball, you’ll see an extraordinary thing. The brain will not see, or will not perceive, the gorilla suit.

And you can ask people that are watching this, ‘Hey, did you see anything weird in that video we just showed you where people were throwing basketballs?’ And they’ll say, ‘No, no.’ And then you tell them, ‘Sorry, there was a person in a gorilla suit that was walking by.’ And what you can show is that even though the photons that bounce off the gorilla suit actually enter into the brain, somewhere along in the brain that gorilla suit is not supposed to be there—that’s not what

happens when you're throwing a basketball—and the brain edits it out. You don't get it into your percept.

So, that's not seeing with your eyes. If you saw with your eyes you'd get the gorilla suit. Nope, you see with your brain. In fact it's so dominant that we have a name for it. We actually call the dominance of the visual processing feature the pictorial superiority effect.

GC: Tell us about the wine tasters.

JM: Well, that's a great example of the pictorial superiority effect. The experiment was how dominant is the visual processing over, say, something like wine tasting or smelling. And so, they took some very fine and refined noses, if you will, from the University of Bordeaux: people that will describe red wines with a very certain vocabulary and white wines also with a very certain vocabulary, and not mix the two. All right, here's the dirty trick. You take these very refined noses from the University of Bordeaux and you do a really dirty trick.

You take some white wine and you put red food coloring in it, and then you give it to these people as a blind taste test. They all look like red wines, and you have these very sophisticated wine tasters, who teach this stuff for a living, taste the normal red wine. And they'll taste it and give you the words with the red wine. But then you give them the wine that has been altered—the white wine with the red food coloring in it—and ask them to describe it. And they will start using the same vocabulary words that they use with red wines. They have identified it as a red wine.

Now, Ginger, it's not a red wine. These are people that make a living off this stuff. But the visual processing features in our brain are so powerful they are dominant. And they will dominate and change your perceptions of things based

solely on visual perception, even if other information from other senses is telling you something contradictory. We call that the pictorial superiority effect.

GC: I think that experiment is pretty convincing.

JM: I think it's pretty hysterical.

GC: I mean you can think of examples from daily life where that happens. You know like when something's a certain color so you expect it to taste a certain way.

JM: Sure. Oh, yes. There are all kinds of things that are like that. And it's just another great example that you really do perceive things with your brain, you don't perceive things with your senses. Most of the time your senses are simply antenna.

[music]

GC: We'll be back with the rest of this interview after a short break.

[music]

GC: What about the whole issue of memory and vision? Why is it so much easier to remember what we see compared to things like when we hear something?

JM: Well, that's a very good question. We don't really fully know the answer to it. In fact, it's kind of a mismatch. We know, for example, that our ability to smell is on the way out, but if you really want to remember certain features of a given stimulus your memory is much clearer if you can associate a smell with it. So, we don't really understand that very well. And this is sometimes called the Proust effect.

You can do this experiment. You can have a bunch of college students go out and see a movie. And then when they're finished with the movie you divide them into two groups and you put them into two rooms, and in each room you ask them, 'Write down as many things as you can remember about the movie.' If in one room you pipe in the smell of popcorn during retrieval—when they're asked to write down what they remembered—you can often get a 40% to 50% increase in their memory retention, in their memory scores, simply by introducing smell.

That's called the Proust effect. We don't really understand the Proust effect. There's some neuroanatomical hand waving you can do. For example, the neurons in the smell system don't directly go deep into the brain into an area we call the thalamus; they go directly into some of the memory processing systems in the brain. But we really don't understand that either. So, I can't answer your very good question.

GC: I like the fact that you ended that chapter with the whole, 'throw away the PowerPoint.'

JM: Oh, gosh yes. Well, one thing you can say is this: there's a hierarchy of visual information processing features. We pay attention to a moving rotating three-dimensional image more than just about anything else. We are built to detect visual motion. The second thing, we are built to detect two-dimensional visual motion. That would be the next thing that our brains pay attention to. I think that's why visual learning is so important. Thirdly we pay attention to static three-dimensional objects, and fourthly we pay attention to static two-dimensional objects. Now, a PowerPoint is a static two-dimensional object. You ought to throw that stuff away.

There's another reason to get rid of your PowerPoint—or at least learn how to animate at a primitive level so that you can have moving objects all the time—and that is the idea of being able to look at letters. When you take a look at a word

your brain doesn't think of words, it thinks of words as tiny little pictures. And it wants to look at all of the various features of those tiny little pictures. So, when you're asking the brain to look at a PowerPoint slide and you have got tons of tiny little pictures, what you see is very simple. You see tons and tons of visual input. The brain actually slows down greatly when it has to look at a word, and in a typical PowerPoint presentation you can easily have 40 words.

Now, you'd think after all these years of reading books, and posters, and computer screens, and cornflake packages, we could train our eyes and brains to recognize common words without that intermediate step of needing to identify the features in the letters. That would be far more efficient. But you can never train your brain to do that, Ginger. A word becomes unreadable unless you can identify the letters separately, and the efficiency is limited by what we really term a bottleneck of having to rigorously and independently detect those simple features. So, get rid of the letters and put up pictures and make them move. That'll make your audiences a lot more attentive.

GC: Yes, I don't think I'm ready for that. I actually have never done a PowerPoint presentation.

JM: Well, don't. Learn to animate instead.

GC: Yes, another thing to learn how to do; which is very good for our brain, to learn how to do new things.

JM: Well, I have a prejudice towards that. I was a professional animator and a graphics artist before I was a scientist. So, I animate my lectures generally.

GC: I got the DVD that comes with your book, also, and that's very nice. So, do you want to say anything else about how people could—and you can refer to some of the other brain rules that we haven't had time to talk about if you want to—just

a little bit about how we can apply what we're learning about the brain in our day-to-day life?

JM: Well, I might conclude our discussion together by saying something that I talk about in the book. The last brain rule is that we are natural explorers. I actually don't know what curiosity is, but I believe in it with all my heart. And the reason why is how I was raised. My mother was a fourth grade teacher; probably the best teacher I ever met, and maybe those are the reasons why I'm interested in information transfer and education. She saw when I was three years old, Ginger, that I was deeply interested in something like dinosaurs. And you know what she'd do? She'd fill the whole house with dinosaurs: manipulatives that I could look at, posters; we would make dinosaur food, you know, something we thought dinosaurs might eat. We did all kinds of things.

And then after a couple of months my interest would wane and then I wouldn't do dinosaurs anymore. And she would wait. Down would come the dinosaur posters and away would go the manipulatives, and she waited till the next thing, which might be spacecraft, and outer space, and solar systems. If it was, then you know what would happen? Up to the whole house would come Saturn, and Jupiter, and all things space. And I got it after awhile as a little boy, that my curiosity meant everything to her.

If there was anything practical I would say, I would say to those parents that are out there who have little children, or even bigger children, or have grandchildren, embrace, envelope, and do everything you can to aid their natural curiosity. She did, and it turned me into a scientist. And I could never get away from it.

GC: Your story about her, first of all you were demonstrating all the principles of your book just by telling that story.

JM: Yes. Actually you don't have to read the book. Just read that story and save yourself some money.

GC: What are you working on now?

JM: Oh, dear. Well I have a number of research projects that are going on. I'm doing a fair amount of consulting, working on a cancer-related project. And I've got three projects in the works with a school district, which is really a lot of fun. We're doing an exercise experiment whereby we're actually taking a bunch of fourth graders and aerobically exercising them, and then looking for changes in their grades and their executive function.

And we're also doing an experiment whereby we're actually doing that repetition thing, where we'll take a bunch of third graders and when they're learning their multiplication tables we are literally repeating the lecture 120 minutes later. By the way, one of those studies has just been completed and we have gotten a 14% increase in their overall retention.

So, we think this stuff really works, and we think we're onto something with it and are desperately trying to combine the science of learning with the practice of learning. Even though we don't know squat about how the brain works, we know 12 things about how the brain processes information, and those we could capture and harness in good research experiments and maybe change the world. At least that's the reason to write the book.

GC: I'm going to link to your book and your website, but you might want to tell my audience how to get to your website.

JM: OK, sure. It's www.brainrules.net.

GC: Tell us a little bit about your website, because I think it's not the typical book website.

JM: No, this is the brainchild of my publisher, Mark Pearson of Pear Press. He had an extraordinary vision, and in looking over at the brain rules themselves, knew fully well that we were visual processors of information, and that there was movement involved, and that people really were hungry for solid reproducible data. So, he had the great idea of having a lot of visual presentations imbedded in the website itself, and all 12 rules.

If you go through that it's actually a mini-course for each of the rules whereby we say six or seven things about them, and provide for the audience references and actually the graphs from the research papers themselves, so that our audience can take a look and see for themselves rather than trying to take my word for it in a book. And we've animated those, and the effects are fairly brain-friendly. And then we also included in the book a DVD in the same spirit. So, there are three ways to get at the information within the book: either the book itself, the DVD that comes with it which is a summary of all the rules, or to go onto the website and then go through the tutorial section on each of the 12 rules.

GC: Is your book available as audio? Do you happen to know if it's on Audible.com?

JM: Yes, it is. I don't know about Audible.com but there is an audio version of it, and I know you can pick it up on Amazon.com. And actually you can pick it up through the website too. There are several ways to do that.

GC: Is there anything that you think is important that we left out that you really would like to share before we close?

JM: Well, there's one thing we didn't talk very much about, and that is stress. The brain rule is that stressed brains don't learn the same way as non-stressed brains. And one of the most toxic environments I think we can have in this day and age is the modern American work force. We often tout ourselves as being the

most productive in the world, but man, we're paying the price for it. There is a very particular type of stress which is not good for learning. Some types of stress I think actually are good for learning, but there is one particular type of stress that is not good for learning and that's the type of stress we call learned helplessness. And maybe this is what I can leave us with.

Learned helplessness is an inability to control the aversive stimuli that are coming at you. You can't control the frequency of it, i.e. you can't control the number of times you get hit and you can't control the depth of the aversion once the aversive stimulus has arrived at your doorstep. The more out of control you feel over those things in your life—the awful things that happen to you—the more likely you are to experience the type of stress that will result in a cognitive collapse, actually into a depression if you're not careful.

And so, in the book I try to talk a little bit about the fact that the brain was never designed to deal with stress on a long-term, chronic basis. It was only designed to deal with stress in 30-second, 1-minute increments. The saber tooth tiger either ate you or you ran away from it, but it's all over in less than a minute. Does that make sense? So, if you have a 30-second implementer but you now overlay civilization over it, all of a sudden you can be in a bad marriage that can last for years, you can be in a bad job that can last for years. You are increasingly out of control of the things that are bugging you.

And when that occurs you're dead in the water and there's nothing you can do. That's the type of stress you need to avoid. So, what I do is I encourage people at a practical level when they are stressed to figure out the type of stress, where it is bad for you. Because not all stress is bad. But the type of stress that is bad is where you feel out of control. And then, for God's sake, get out of the situation that will lead you to feeling out of control

GC: Well, that's good advice for sure.

JM: Well, thanks.

GC: John, I really enjoyed talking to you, and I want to thank you again for coming on the podcast.

JM: My pleasure, Ginger. A pleasure to meet you.

GC: And I hope that you have lots of luck in getting your book out to people. Mark seems to be a very innovative publisher.

JM: Oh, he's terrific. Yes, I've had so much fun working with him. It's been a blast to be able to work with Mark Pearson of Pear Press.

GC: And I will mention that I have seen your book at Barnes and Noble, so I don't think people will have any trouble finding it.

JM: Excellent. Oh, that's good to hear.

[music]

Many of you may be wondering why this interview isn't longer. John had to go to a meeting, so we had to cut it just a little bit short. But I definitely want to thank John Medina for coming on to the *Brain Science Podcast*, and I highly recommend his book, *Brain Rules*. You can pick it up everywhere. It is available on Audible.com. And don't forget that you can get this book as your free download if you join Audible.com. The link for that is audiblepodcast.com/brainscience. The last time I looked it was #2 on the Psychology and Mind best-seller list, right behind *Predictably Irrational*. If you haven't yet heard the interview of Dan Ariely, the author of *Predictably Irrational*, you need to check out my other podcast, *Books and Ideas*. Anyway, the book is available in audio and also there are links to the book and the book's website—which has a lot of audiovisual information—that is all available at brainsciencepodcast.com.

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I have some interesting interviews coming up. I'm really excited about the fact that I have an interview with Jeff Hawkins, who wrote *On Intelligence*, because that was the basis of Episode 2 of the *Brain Science Podcast*, and indirectly his book, *On Intelligence*, was what motivated me to start this podcast. So, I'm looking forward to that. That should be out in a couple of weeks. I also have an interview with Michael Arbib. We're going to be talking about his Mirror Neuron Hypothesis of language. I hope you'll be back to listen to those interviews.

Thanks again for listening. I look forward to talking to you again in a couple of weeks.

[music]

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