find your passion strengthen your brain

A Q&A WITH DR. ADELE DIAMOND

by James Sullivan

Dr. Adele Diamond is currently a Tier 1 Canada Research Chair Professor of Developmental Cognitive Neuroscience at the University of British Columbia (a distinction she has held since 2004), is a Fellow of the Royal Society of Canada, and has been named one of the 30 most-influential neuroscientists active in the field today. She was among the researchers to pioneer developmental cognitive neuroscience, an interdisciplinary scientific field that studies the development of thought processes as they occur in the brain.

Much of Diamond's research focuses on the human brain during the stages of growing up. Among her interests are creative and flexible problem-solving, meeting unanticipated challenges, self-control, the ability to reason, the determination to follow through, and finding success in all facets of life. She has given a number of TED Talk presentations on fostering creative abilities in children at an early age and encouraging outside-the-box thinking, and also made an appearance on NPR's radio program On Being with Krista Tippett, where she talked about how the arts can be applied to problem-solving.

Brain World recently had the opportunity to sit down with Diamond and talk about her longtime interest in neuroscience and her latest research endeavors.

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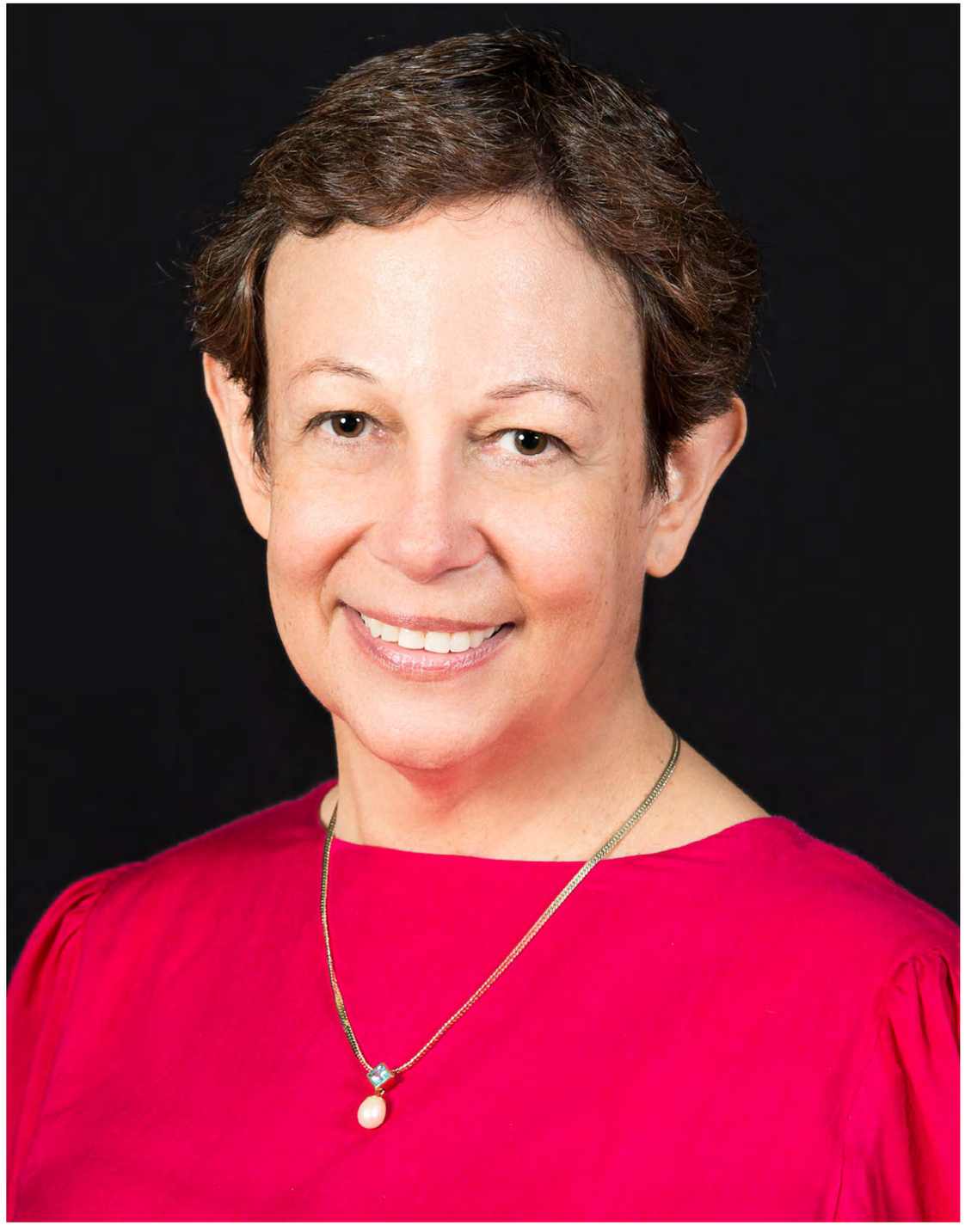

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Brain World: So one of the first things I noticed was that you studied anthropology before you became interested in neuroscience. How did that transition work?

Adele Diamond: That's a bit of a long story. I was never interested in the more scientific side of psychology or biology or anything like that. I was interested in the development of the person in social and cultural contexts.

When I went to graduate school, Harvard gave me permission to work in three different departments. My home was psychology, but they let me work in sociology and anthropology. I had outside funding but also got some funding for a training grant in cross-cultural research where they prepare you for one year to go into the field, one year to go any place in the world you wanted to go, and I chose the South Pacific because it was the most idyllic place I could think of.

I was planning to do this for my dissertation. My idea was that a lot of what we read in the West says that if you don't feel like you're in control, if you don't feel like the master of your fate, you become depressed. Even suicidal. But I wasn't sure that was an intrinsic human quality, like everything I was reading had said or something that was the product of culture.

I had all these hypotheses about why it might be different in a non-Western culture. The problem was that as I started to develop the research plan to do this, I didn't think I was coming up with a good way to study it, because the more you think about it, the more slippery being in control means, because you can be in control in subtle ways that aren't obvious.

I had very famous people over at Harvard advising me, who said I'd do fine and I was thinking these guys are looney — I'm not going to paradise to be miserable for the year. I ended up giving the money back and said I'd re-apply.

So my first year in graduate school, Jerome Kagan [psychologist] proposed the question: "If infants all over the world show the same cognitive changes at roughly the same time, those changes cannot be due entirely to learning or experience, because their experiences are too diverse; there must be a maturational component — what might that maturational component be?"

Africa, Asia, West Europe. Kibbutz. Communal living, family living. Doesn't matter. So if their experiences are so different, but timetables are so similar, there has to be a maturational component. He was so excited about this that you couldn't help getting interested, but to answer that, I had to study neuroscience. I had to look at the brain. That was sort of weird at Harvard at that time. They didn't have anyone to study the brain. When I asked to put someone on my dissertation committee, it had to be someone from outside who knew about prefrontal cortexes and stuff, to see if what I was doing made sense.

I never intended to go into neuroscience. It was only because my original research topic didn't work out. It was a complete surprise. I'm still an anthropologist in the sense that I look at the behavior — not just at the numbers.

BW: A lot of your research concerns executive functions of the brain. What are executive functions?

AD: Executive functions are the collections of skills that depend on prefrontal cortex and interrelated neural regions of the brain. They include things like self-control and being able to control your attention so that you stay focused. That's under inhibitory control. Then there's working memory, holding information in the mind and working with it — like mental math calculations or re-ordering items on a to-do list or relating thoughts and ideas among each other. Then there's cognitive flexibility — being able to see the same thing from different perspectives, being able to flexibly adjust to change. Being able to think outside the box. Those are important for reasoning, for problem-solving, decision-making, planning, stuff like that.

BW: How does the prefrontal cortex work in carrying out all these functions?

AD: That's a huge question. It seems like one of the things it does for working memory is it sustains the firing rate of neurons during the brief time that you're holding the information in mind. They're literally keeping the information active by staying active. You can see if someone remembers something by looking at whether the neurons in the prefrontal cortex are firing or not.

Earl Miller's work on monkey brains shows that neurons change the direction of their firing to help you think about a problem in different ways, and you can see that change at the neuronal level in the prefrontal cortex when you try a different perspective. How it exercises inhibitory control is more by putting the brakes on lower areas of the brain, so for example with the amygdala screaming because you got really scared, the prefrontal cortex will kind of calm down the amygdala. One of the ways it does the stopping is through the subthalamic nucleus — very important when you need to not respond right away, so you can have a better response than the first one that occurs to you.

BW: How early can these executive functions be seen?

AD: Well, my dissertation, which was ages ago, says you can see it develop at a rudimentary level between 6 and 12 months of age, or more precisely, around 9.5 months. You can see the beginning of working memory, of inhibitory control, and on a very small level, the beginning of cognitive flexibility, which really comes in later than the other two.

I was doing my assessments by having babies reach for things. If you have them just look at things, then it looks like it could be even earlier — 5 months maybe. It begins to develop during the first year of life, which is much earlier than the experts thought — they thought it didn't do anything during the first year. However, it takes a very long time to fully develop, not until your mid-20s.

BW: You also talk about external versus genetic factors in the development of executive functions. What are some of those?

AD: For external factors, the prefrontal cortex is the most vulnerable area of the brain, so if something isn't right in your life — if you're alone, if you're sad, if you're stressed, if you're not physically fit — that delays the development of the prefrontal cortex.

For example, if a child experiences something really awful — a parent dies or the child witnesses some violence, or is picked on at school — that delays the development of executive functions, meaning the development of the prefrontal cortex.

Then there are genetic factors — for example, the COMT gene (catechol-O-methyltransferase). If you have the Met variant of the gene, you'll have better executive function at baseline but you're also more sensitive to stress, have a lower pain threshold, and are more vulnerable to mental disorders. So in a situation of mild stress, people who have the Val version of the COMT gene now look better, as they are calmer in the face of stress — they can withstand more stress before it affects the prefrontal cortex in an adverse way.

I've said that COMT Vals look like the picture of resilience in a bad situation, but a child who is COMT Met, even though he or she looks really bad, in a bad situation, has the potential to shine even more than the COMT Val if you can get that child in a good situation, because the COMT Met can get the best tuning of the prefrontal cortex. A child who looks like a disaster in one situation can blossom to be amazing, if only you can find a good situation for that child.

BW: You've done a lot of writing on the best ways to encourage executive functions, particularly in the classroom — what are some of those ways that we can keep our executive functions actively growing?

AD: You need to train and challenge executive functions — and you need to keep on challenging them. You need to increase the difficulty of executive-function requirements of whatever you're doing, so the kids continue to develop them, but you also have to work on the things that I talked about earlier — that the child has to feel calm and cared about in the school classroom and, ideally, at home as well.

If you can develop good relationships in the classroom, especially with the child and the teacher, and the child is securely attached at home, that is extremely important for the development of executive functions and the child doing well. You can have the best things for developing executive functions, but if the child doesn't like it and doesn't do it much, it's not going to improve executive functions.

You need something that not only challenges executive functions, but something that will hold the child's interest and keep them motivated. You really need something that emotionally connects with the child — often, that is something in the arts, but also something demanding physical activity, sports for example. This will grab a child's passion more than school subjects — but it could be something else. It could be caring for an animal. It could be community service, or working on a larger project for the school that gets the child extremely invested.

An important way to have kids invested in something is to let them have a say in the planning of that, and in the development of that, even at the level of discipline in the classroom. If the kids participate with the teacher at the beginning of the year in putting together a code of conduct, the kids are much more likely to behave in accord with that code of conduct than if it's just given to them by the teacher.

BW: So essentially, to find their passion. What they're good at.

AD: Exactly! Finding their passion and something that requires executive functions and keeps on challenging them. Nine times out of 10, it'll be something that if you're able to use executive functions for, you'll do it better.

BW: You've also done some work involving attention-deficit hyperactivity disorder. How can using executive functions combat cognitive disorders?

AD: ADHD is primarily a problem with executive functions. Impulsivity, problems with attention and with working memory are all problems with executive functions — so again, working to train them, challenge them, and find something that grabs the child's passion is

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the best way to improve executive functions. Meds can help a little bit, but often the right dose for controlling hyperactive behavior can be too high for the prefrontal cortex and executive functions, so you have a child who isn't making any waves, isn't hurting anybody, but isn't getting anything done, isn't taking instruction. You want to have a safe dosage for the prefrontal cortex and not just for the lower areas that control hyperactivity.

BW: What do you feel is the most significant study that you've contributed to in neuroscience, if you had to choose?

AD: I would say two. The body and data that was my dissertation in postdoc, where I really made a paradigm shift in how we thought about the prefrontal cortex, about cognitive development, and about being able to study brain-behavior relationships, early in human life, and that really lead to the field of developmental cognitive neuroscience.

And then my work on phenylketonuria [an inability to metabolize phenylalanine, a condition causing brain and nerve damage] — the work with the animal model and the work with the children, because I showed that people had no disadvantage with executive-function deficits if they were on what was considered adequate treatment, but nobody was listening to that because it didn't make sense. They couldn't imagine that if the whole body was getting too much [of the amino acid] phenylalanine, that one area of the brain is affected and nothing else. It didn't make sense. So I demonstrated the mechanism by which this occurred, and then I demonstrated that if you just put them on a stricter diet, that it could prevent these deficits, and then other people after me showed that it could reverse these deficits. So that was a big deal in terms of improving the lives of all the kids with phenylketonuria. We showed that if they didn't start them on diets earlier than the norm, they had settled visual deficits, and it was easier to start them earlier — so that helped children not have a small visual problem that they otherwise would have had.

BW: What advice would you have for someone looking for a career in neuroscience?

AD: First of all, I would say you need to follow your passion. You need to have something that really interests you — not go into neuroscience because someone tells you it's a good field to go into. I think you should also find your own passion in neuroscience and not have somebody tell you what the best field in neuroscience is. I think for graduate school, people should go to a place where there is more than one professor they might be interested in working with — so if one thing doesn't work out, they aren't stranded, there's other people they can work with. I also prefer in graduate school that the students be allowed to work on a project that is their own idea — as opposed to a piece of a project that is their adviser's idea or that an adviser tells them to carry out. ■