“The Brain’s Emotional Development” with Nim Tottenham

Transcript of Cerebrum Podcast

Guest: Nim Tottenham, Ph.D., author of “The Brain’s Emotional Development,” is an associate professor of psychology at Columbia University and director of the Developmental Affective Neuroscience Laboratory. Her research examines brain development underlying emotional behavior in humans, and highlights fundamental changes in brain circuitry across development and the powerful role that early experiences, such as caregiving and stress, have on the construction of these circuits. Tottenham has authored over 80 journal articles and book chapters and is a frequent lecturer both nationally and internationally on human brain and emotional development. She is a recipient of the National Institute of Mental Health Biobehavioral Research Award for Innovative New Scientists (BRAINS), the American Psychological Association’s Distinguished Scientific Award for Early Career Contribution to Psychology, and the Developmental Science Early Career Researcher Prize.

Host: Bill Glovin serves as editor of *Cerebrum* and the *Cerebrum Anthology: Emerging Issues in Brain Science*. He is also executive editor of the Dana Press and *Brain in the News*. Prior to joining the Dana Foundation, Mr. Glovin was senior editor of *Rutgers Magazine* and editor of *Rutgers Focus*. He has served as managing editor of *New Jersey Success*, editor of *New Jersey Business* magazine, and as a staff writer at *The Record* newspaper in Hackensack, NJ. Mr. Glovin has won 20 writing awards from the Society of Professional Journalists of New Jersey and the Council for Advancement and Support of Education. He has a B.A. in Journalism from George Washington University.

Bill Glovin: From our earliest days, the brain develops thinking, mobility and communication skills, but not quite as quick to develop are the parts of the brain that regulate and process our emotions. The research that is helping scientists to learn about areas crucial to emotional development could have far reaching implications for both parents and policy makers.

Hi. I'm *Cerebrum* editor, Bill Glovin, and our guest on this month's podcast is Nim Tottenham, an associate professor of psychology at Columbia University, where she directs the Developmental Neuroscience Lab. She's also the author of this month's *Cerebrum* article, “The Brain's Emotional Development.” You can access the article at dana.org. Dr. Tottenham examines brain development underlying emotional behavior in humans, and the powerful role that early experiences, such as caregiving and stress, have on the construction of brain circuits. She is a frequent lecturer and recently appeared on a panel at the world science festival in New York City on the Human Connectome Project. She has won major awards for young scientists from NIMH and the American Psychological Association.

Welcome Dr. Tottenham. Let's begin with ...

Emotion seems like such a hard thing to quantify since people tend to react very differently to the same event. Is it our environment that shapes us emotionally, or differences in the brain, or both?

Nim Tottenham: Certainly, I think, most scientists would agree that any type of complex behavior is going to be a coming together of both genetic, as well as environmental influences, but one of the things that interests us most is the very long development of these emotional processes, and when something takes so long to develop in the human, by some estimates it's over 20 years, there's got to be a reason for it. One of the reasons that interests us most is that it might be because the environment has a particularly powerful role in influencing many of the individual differences, or as you say, people respond so differently to an emotional event, that people express by the time that they're adults. We spend a lot of time looking at what the environment, particularly the early environment, is doing to influence those individual differences and maturity.

Bill Glovin: How do single events play into emotional development? Let's say, witnessing violence, or even something positive like a birth of a child. That can change someone's outlook forever, can it not?

Nim Tottenham: It's a good question. I'm glad you brought up both, negative as well as positive experiences, because sometimes it's so easy for us to focus on the negative. But those positive experiences are also really powerful because of the trace that they can leave in our brains. I think, one of the important pieces to add on to your question is not only whether it's a single even, as opposed to chronic events, but also when those single events can happen. That leads us to this idea of sensitive periods of brain developments. Are there certain moments in life when a particular event will have an even bigger influence than it will at older ages, and this is one of the questions that really drives developmentalists. The idea that sensitive periods, which are more likely to happen at earlier points in development, are really important to look at because events that happen during those times tend to have more enduring effects on brain development.

To get to your question, there are cases where single events will have a really big impact on the brain. However, more often than not, what people find is that it's the day in, day out routine chronic event, which seem to really lay out these highways in the brain. Now, even a single event in real human life is rarely a single event. A single event often comes along with many, many consequences, so it's really hard to tease apart what's a true single event versus something that kind of changes the day in, day out lives of people.

Bill Glovin: I know you just alluded to sensitive periods, and in the article you discuss sensitive periods versus critical periods. Can you explain to people what those are and the differences?

Nim Tottenham: Briefly and generally, a sensitive period is a time in the development of a certain brain region when it's undergoing really rapid change, really rapid development.

It's during that moment when the environment can have a particularly large impact on the way that structure, that circuitry develops itself. A critical period is a specific type of sensitive period in that it is much less forgiving in terms of timing. Critical periods tend to have a very sudden opening ... If you use a metaphor of a window of opportunity. That window has a sudden opening and a sudden closing, and if you don't get a particular environmental input during that window, it may be nearly impossible to have the environment impact the system at a later point.

A sensitive period has more forgiving borders. You tend to see the opening be more gradual over time, and the closing more gradual over time. One example we can think of is learning a second language. It's much easier to learn a second language during the first decade of life than it is during the second decade of life. That's probably a good example of a sensitive period because it's not that on your tenth birthday all of a sudden the window closes and you're not able to learn a second language, but rather you have a gradual closing. Certainly, people can learn second languages later on in life. It just takes a little bit more effort.

Bill Glovin: That would be more cognition than emotional brain development, right?

Nim Tottenham: That's right. Emotional development, we posit, probably is more likely to fall into the category of sensitive periods, at least in the human, because it tends to have those more gradual opening and closing periods.

Bill Glovin: In terms of emotional brain development, it seems that emotion lags behind cognition and language, and that we also lag behind other species in the rate that we develop our emotions. Why is that?

Nim Tottenham: I think lagging behind relative to other species, it's a good question, because it means many different things. If we look at the proportion of time of development that we spend in an immature, quote, unquote, emotional state, it's really long compared to other species. However, when we finally reach the adult state our emotional abilities, our ability to regular our emotions, make ourselves feel better, make ourselves feel worse, delay our emotion reaction and so on, far exceeds other species. We can think of this as a slow cooking process that we undergo, but you end up with a very sophisticated product at the end.

Bill Glovin: Do other species, for example, like mammals, have all the same areas of the brain that we do?

Nim Tottenham: If we look at the non-human primate brain, they have, at a broad level, the same regions that humans have, but they are far less sophisticated than what's observed in the human. Not only in terms of volume and thickness, but the human has much more surface area in the cortex and the connections between,

for example, this prefrontal regulatory region, and other regions of the brain that tend to be more automatic or reflexive, is much more refined.

Bill Glovin: Is the prefrontal cortex a region of the brain that is very important to emotional brain development?

Nim Tottenham: The prefrontal cortex is a region of the brain that is connected to all other regions of the brain. When we encounter an emotional event, there are many, many processes that are going on at once. For example, our sensory processes have to become engaged, our decision making processes, our motor processes, and all of those contribute to our ultimate emotional reaction. The prefrontal cortex is this critical interstate of all of that information coming in together to help bias our reactions in one direction or another.

Bill Glovin: Common sense would tell us that physical changes such as puberty would play a huge role in emotional development. Is that true?

Nim Tottenham: Certainly. Many studies have now shown that that transition between childhood into adolescence, which is often coinciding with pubetal development, is another big moment in brain development that supports emotional behaviors. Perhaps, not coincidentally, that's also a time when people might be at a heightened vulnerability for expressing certain psychiatric illnesses that we associate with emotional dysregulation.

Bill Glovin: Is there a different between the sexes and the way emotion develops?

Nim Tottenham: Across large studies, people often find that that moment of pubetal transition does mark a point when studies start to find larger sex differences. For example, females are at greater risk for exhibiting what are often called internalizing disorders. Things like anxiety and depression, whereas males are at greater risk for exhibiting what we typically call externalizing problems. Conduct problems or ADHD.

Bill Glovin: There's even great emotional disparity between people of the same gender. Why is that?

Nim Tottenham: Are you talking about individual differences between one person and another?

Bill Glovin: Yes. Of the same gender.

Nim Tottenham: Right. That is an important piece, an important part of the gender different stories that often what people find is there are enlarged samples, group differences, where males are more likely to do one thing and females are more likely to do another, but if you look at the individual ... For example, one female to another, often those differences can far out exceed the differences between males and females. That really speaks to the individual differences in emotional behaviors between one person or another.

Bill Glovin: I noticed on your website that you invite the public to come into your lab and be studied. Take me through the process of that and maybe talk a little about imaging advances and how that's plays into research.

Nim Tottenham: We invite research participants starting as young as the preschool period into the laboratory. Because we're working with young children and families, we pay a lot of attention to the emotional experience of coming into the laboratory. We make it a very child friendly, childlike experience and, in the process, we have children play games. We call them games, but they're really neuropsychological tests, they're computer games that are all designed to be fun for children, but scientifically informative for us. We can ask children to play some of those computer games while they're getting an MRI scan with special equipment that allow children to see a computer screen while they're in the MRI and press buttons on a little button press to give us their responses.

This is a way for us to safely get pictures of brain activity from healthy awake children. This is really a relatively new science. The first paper that was published using functional MRI in healthy children while they're performing a cognitive task was published Casey in the mid-90s, which is really not that long ago. It's a very exciting time in developmental science because with the advent of (f)MRI, functional MRI, as a technology, we're able to, for the first time in human history, look at what children's brains are doing when they're healthy and awake and performing a task, or responding to an emotional stimulus.

Bill Glovin: In the article, you allude to something called threat learning. Can you explain what that is?

Nim Tottenham: Threat learning is a very basic fundamental way that we learn about what's safe and dangerous in the environment. This paradigm really builds off of some of Pavlov's initial studies with dogs where, if you remember, he paired a bell with some meat odor and, over time, he could just present the bell without the meat odor, and the bell itself would produce salivation in the dogs. That is a form of learning or conditioning to a particular stimulus. This is a way that we learn about the environment every day.

For example, if I encounter some kind of dog and the dog might nip at me, I will quickly learn that the sight of a dog will be associated with something negative or threatening. For me, the sight of the dog in the future might be enough to elicit a threat response in me. We can use that paradigm in the laboratory whether we're studying children or whether we're studying bats. This is a standard paradigm that people have used and you can take an initially neutral stimulus like a tone, a bell, and pair it with something that is not pleasant, and study one's ability to learn that that initially neutral stimulus is no longer pleasant.

Bill Glovin: Interesting. Does emotional brain development research have implications for parents and policy makers?

Nim Tottenham: I think it does. I think it has a lot of information to offer both parents and policy makers. One of the most important messages is that the environment matters. We often think about the brain and the environment as being two separate entities, but they're truly interdependent on one another. We have to pay attention to environments, particular early environments. It's amazing how often people may not think about the environments that children are experiencing, whether they're positive or averse in any way.

I think that's one really important message. The second important message is the concept of plasticity, which we haven't used that word, but it's implicit in everything we've been talking about. Plasticity is the property of the brain to respond to the environment, that includes adverse environments, but also respond to positive environments. That becomes really important when we start thinking about resilience in individuals or recovery following, for example, an adverse experience. That's one of the really exciting areas of research now, which is to try and understand individuals that are exposed to early adverse experiences, how can we leverage that plasticity at later points in development to change paths that people are on?

Bill Glovin: That stole my thunder from my last question, which is what are you currently working on and what are a few key things we still need to learn about emotional brain development. Obviously, plasticity is a key, I guess.

Nim Tottenham: I would say that's a big one. In addition, if I can add to that, I would say we are still at the very early stages of understanding how the environment influences the brain. We've made great strides and made many important discoveries, but I think that we can improve on our ability to understand or predict how brain development is going to ensure in any particular child. We don't know with certainty which child is going to struggle as a consequence of experiencing, for example, an early adverse environment versus those that despite experience that early adverse environment, is going to continue to thrive. That's a really important piece of the puzzle that we don't have that would influence how we promote health brain development.

Bill Glovin: Thinking about this terrible opioid epidemic now, especially concerning young people, I'm sure there's maybe something in the environment or the early learning process that could be tied to that, for example, to just get back to implications from policy makers and parents.

Nim Tottenham: That's the challenge with human studies; that the human environment is so incredibly complex. Just to use the example that you gave, with opioid exposure it's that often there are many things that are correlating with early opioid exposure. It's hard, in the human, to disentangle which environment was the one that was most associated with a particular outcome. This is where translational science or the ability to go back and forth between human studies and animal models becomes really important. In animal models you can ask those questions with much more experimental control and precision.

Bill Glovin: Is there anything I have left out that you think is important to address?

Nim Tottenham: I think you've asked all the important questions.

Bill Glovin: Great. Okay. Thank you so much, again. These podcasts have proved very popular and hopefully this will help people who are too lazy to read the article. They can kind of get this and it's a little easier to digest somehow.

Nim Tottenham: Great.

Bill Glovin: Thanks again. I think you did an amazing job, and everybody was just so pleased.

Nim Tottenham: I'm glad to hear that. You were terrific to work with. The editing process. I've actually never worked with an editor before. You've been wonderful.

Bill Glovin: Oh wow.

Nim Tottenham: I said, "Oh," I said, "Do this for all of my papers now."

Bill Glovin: Sure. Okay.

Nim Tottenham: Also, I have to say your publicity has been great because I've had so many people contact me more about this paper than other papers that I write. Your team's been doing a great job.

Bill Glovin: Fantastic. Okay, Nim. Thanks very much and have a great rest of the summer.

Nim Tottenham: You too, Bill. Thanks a lot. Bye, bye.

Bill Glovin: Bye, bye.

That's our *Cerebrum* podcast for this month. Again, you can find Nim's article and all our Dana Foundation content on the latest in brain research at dana.org. Join us next month when we talk to Richard Doty, one of the pioneers of olfaction research and the author of our next *Cerebrum* article, “Olfaction, Smell of Change in the Air.” Doty is director of the University of Pennsylvania Smell and Taste Center, and the inventor of the University’S Smell Identification Test. I'm Bill Glovin. Bye for now, and thanks for listening.