Interview Transcripts

International Edition

Names starting with N to S

This document contains transcripts of the expert interviews in *Introduction to The Science of Early Child Development, International Edition*. Transcripts are listed alphabetically by the name of the interviewee and the name of the video clip. Click on a name below to go to that person's interview transcripts:

Ndeto – stealing education (4:45)

My name is Nehemiah Ndeta and I'm the programme Director here, Kwa Watoto Centre and School which was established in 1999. And right now it has a population of 820 children that is in primary and 600 in high school. Actually, it got started – I had an idea when I was growing up because I went through school in a very difficult way. My father died when I was still a very young boy and I was the last born of my family. And so, the other siblings ahead of me had never gone to high school. When my father died I started being sent home right in primary, there is no free primary at that time. So, when they used to send me home I used to ask myself, "If my brothers and sisters ahead of me never went to high school, they just finished primary and they're not able to survive, what I am going to do that I cannot be able to finish primary?" And so when the Headmaster used to send me home to go and get school fees because I knew there was no school fees at home, and my mother was disabled because she was partially deaf and she couldn't do any meaningful job. So what I used to do was when they send me out through the door I could come back through the window and sit back in class and continue learning. So when the end of term comes, I am at top of the class, and so they used to wonder, "How this boy, we are always sending him home, how does he become number one again?" And so they discovered that I was coming back and so one day they made a trap and they send me home and they came back and all the teachers came and found me in class. And it was one July morning, I can remember it very, very well and they told me "Nehemiah you have been stealing education in this place". Then I told them that I would rather be a thief of education than be a thief of property. Cause I knew if I don't get that education I was going to steal because I had to survive. And so I told them "I am going to steal from you if you don't let me be in school. So I'm just asking you to let me be in school and then I will be a good person in life".

And so they let me be in school. I did my Grade 8 and somebody told me that 'if you do very well, we are going to get you to a school that is going to support you free of charge. That is going to give you a free secondary education. Because that was my next worry because none of my siblings had gone to high school 'cause we didn't have any money to pay. When they did that I went to high school, Starehe Boys' Centre and School, which is a national high school well known in Kenya. It is doing very well academically so I went through that school and that was the end of my worries, when I was admitted into Starehe Boys' Centre. And when you're living at Starehe Boys' Centre, the Director of that school, his name was Dr. Geoffrey William Griffin, who died just a few years ago. He used to ask every one of us, "What are you going to do to give back to community? What has Starehe given you?" And so without even thinking, without realizing what I was saying, I said that I was going to give back to community, give some children an education. And I didn't know how I was going to do that or when I was going to do that. But it came so fast, because after I left school I worked for a short while. I had a contract with UNICEF for some time to go around to get the children who are out of school. And so I found out that in several slums there were many other schools that were giving free primary education. Then I found that within Soweto, where we're standing now, there were only two schools that were giving free primary education. And there were 10,000 children who are not going to school, who are supposed to be in school. And then I said, this is where I said I want to start … And so I came here and I started in 1999 and the first day when we opened our doors on the 6th of February, 1999, we had 150 children. It was an overwhelming number because I didn't expect the parents or the children to respond in that great number the very first day. And so we started, and from that day we have never had less. They are always coming and coming and

coming. And so we started in very poor shacks around here but now, due to well-wishers and commitment from donors and well-wishers we've been able to put up what is here. And so, we thank all those people who have done all this to make it come true because the children are at least right now they can now be able to sit in a class which is cool, not as hot. But we are still having about 90 children in every class. We need to split it up so that at least we can have quality in our education but we are happy up to where we are. We know that we can, in the future we shall go far.

Nelson – BEIP age 8 results (4:11)

The Bucharest early intervention project is now roughly in year 12. Our children are now 12 years of age. We're following them up right now. We have no data from when they're 12 because we just started, but we do have data all the way through eight years. The storyline that we see at eight is very similar to what we reported when they were much younger. It turns out that living in an institution leads to profound deficits in virtually every domain that we've looked at: IQ, language, brain development, growth, things like that. If you look at children placed in our foster care intervention placed in families, in most domains, children benefit greatly. We don't see yet that we're bringing them up to what we would consider to be typical development, so their IQs jump from 75 to 85 or upper 80s, but we're not seeing IQs of 100. The last part, and I think the more important part from a neuro-science perspective, is that in the domains that we see the intervention working, some domains have a sensitive period attached to that other domains do not. So an example of that would be for IQ, for EEG, for language, we see that children placed roughly before 22-24 months do much better than children placed after that age.

There are a few domains where we see an intervention effect, but no timing effect. An example there is that we see dramatic reduction in children experiencing anxiety or depression, but it doesn't matter how old they were when they went into foster care, no matter how old they are, they get less anxious and less depressed. There are, however, a few domains where we're really not seeing any intervention effects at all. So we're not seeing really an improvement in executive functions, and related to that is we haven't seen a dimunition in what we call externalizing behaviour problems like attention deficit disorder or conduct disorder. So the children placed in foster care are not showing any less ADHD than kids who stay in the institution.

Now we think that the reason for this could be that the average age of placement was about 22 months so its entirely possible we placed the kids too late. If that's the case though that means the neuro circuits that underlie things like ADHD are getting set up before the age of two, which begs the question of how early in life we should be screening kids for ADHD.

So one question I've often gotten is why is the BEIP as we call it so important? What's new about it? First of all it turns out that there are very few studies that have ever looked at currently institutionalized children at a large sample, and none have ever looked at this from the lens of neuro-science biology. Second, this was an intervention study and it allowed us to test the question of sensitive periods. Whether kids placed in more favourable environments at particular points in development would do better. There are lots of monkey studies like this but none with humans. So I think the lessons we've learned from this that are most critical is that there are sensitive periods in human development. That children taken out of really adverse circumstances and put into much better circumstances, better families, at or before particular points in development can really benefit even if those children might have been handicapped in some way to begin with.

And I think the last thing is it's given us a clue as to the mechanism. So, at the AAAS meeting last week in Vancouver, someone said to me "what didn't we already know about your findings?" and I said well, we weren't entirely

surprised that kids who grow up in institutions don't do very well, but now we know why, with our biological data and our neuro-science data, we have some handle as to what is going wrong in brain development that leads to children having anxiety or ADHD and the like, so I think that's the last lesson, can we not only describe the effects of early life adversity, but can we explain why those effects cause the damage that they do.

Nelson – brain and memory development (5:18)

Now in memory the goal here was to understand what are the areas of the brain that develop over the first one to two years of life that facilitate the development of memory? And then to be more specific in the type of memory we look at so we no longer think that there's a type of memory. There's probably different types of memory so memory for what you had for breakfast this morning or the name of the teacher you had in Grade 10 English is quite different than memory for riding a bicycle or playing an instrument. And so our goal is to understand the different types of memory, their development on a trajectory and what parts of the brain are facilitating that development over the first two years of life.

And what we find there is that we see a very early form of memory that depends primarily on a single structure in the brain called the hippocampus which lies deep in the brain and it's hard to show you but this is the outside surface and this is the inside. It's a structure that lies in here. Basically in the mid-point between your two ears almost. And that's called the hippocampus. We know that that matures a little bit early. We know that that matures in the first month or two to the point where young infants have some evidence of, can show evidence of memory. But over the next several months that area of the brain and areas in the other portions of the temporal lobe which is the part of the brain right above your ear, right through here, start to mature more, making possible more sophisticated forms of memory and the ability to remember things for longer periods of time.

And then the last event probably is long-term memory. So most of us are familiar with the following phenomenon. I say to you: What's your earliest memory? How old were you? And what most people report is that they were usually not younger than two; on average three or four for those early memories. Every now and then you'll find somebody who was twenty or twenty-two months but the accuracy is a little bit questionable. So that leaves open the possibility of, that leads to the question of so why is it we don't remember the events of our lives before the age of two. And one possibility, in our view, is that the areas of the brain that store memories for the long term are not in the temporal lobe or in the hippocampus but they're outside. And those areas develop slowly. And so as kids get beyond the age of two those storage sites for long-term memories develop.

And then the last event is that we all know, some of us more than others, that as we get older, our memory starts to not be as good and we need the little tricks for learning how to remember things. Those are mnemonics. So you repeat something over and over again and you remember to write it down. Things like that. The frontal lobes play an important role in our use of strategies, the little tricks we use to help us remember. And the frontal lobes mature slowly and very late. They don't really start to mature in a big way until four, five or six. And it's not until really adolescence that they're much more mature. And so the last change in memory would then be the facilitation of memory based on development of the frontal lobe. And that's why children, when they're four, would do the following: If I say to you: I'm going to say some numbers. How many can you remember? You might say six or seven. If I say to a four-year old: I'm going to say some numbers out loud, how many can you remember? They might say 25. So you'd give them some numbers and they'd remember on average, four. So then you say, Ok, let's do it again. How many do you think you can remember this time? And they'd say 30. They have no perspective that things can be

forgotten, in part because they haven't developed the strategies to help them remember because the areas of the frontal lobe are immature.

So those are sort of our studies of memory. Again, in babies we focus on recording the neural correlates, or the electrical activities we associate with memory and as kids get to be five or six we can actually look at the anatomy of their brain by doing functional magnetic resonance imagery. The last thing I'll add about memory is that a big focus of our work, particularly the applied side, is that we're not only interested in how memory develops in typically developing children but what happens in children at risk for problems with their memory or other cognitive functions?

So we spend a lot of time looking at infants and children, particularly infants who suffered various pre or perinatal brain injuries that may predispose them to having problems in cognitive development, particularly memory development. And the goal there is not only to track their development but as well to develop the tools that will allow us to identify those babies much earlier than we were ever able to before. Typically a learning disability isn't diagnosed until kids are school age. And if we can, in a sense, flag children at risk for a learning disability when they're a month old, or six months old, then we can intervene much sooner. And the last part is that the tools we use to study these things and event-related potentials, can be used to evaluate any intervention. So an example would be if we know what a normative brain response looks like in a memory task and what an abnormal brain response looks like, if we do an intervention, can we see that abnormal response becoming a normal response? So then we have an outcome measure in our intervention. So that's the application part to the work on memory.

Nelson – Bucharest early intervention project (6:37)

So, I have the distinction of being able to direct a research network that's concerned with the effects of early experience on brain development. And we actually have a web site which is www.macbrain.org. Now in this group of researchers, there's about nine or ten of us together who work together which includes developmental neural scientists, psychologist, psychiatrists, pediatricians and the like. What we're trying to understand is the role of experience in influencing brain and behavioral development. A common way to do that is to look at the effects of early adverse experiences. So it's of course ideally the case that we would understand how good experiences affect brain development but one way to infer the role of experience is to see when they're bad experiences. And common in different parts of the world but particularly in Eastern Europe including Russia and Romania and places like that and in Asia like China there are countless children who are abandoned at birth because their parents, for one reason or another, can't take care of them. And these children are typically placed in institutions or orphanages. An orphanage is not a good name for these in part because it sounds like the child is an orphan and in fact rarely are they orphaned, they're simply abandoned. So their parents still are their parents on paper even though they never see the child. So by the late 1980s or early 1990s in Romania there were over 100,000 children in that country who had been essentially abandoned in these institutions and were being brought up by the state.

And the concern is that these are not optimal living conditions. As a rule for example, with babies, there might be as many as 15-20 babies being taken care of by one person. And of course anyone who's had children or works with children knows that that's not optimal. For example, we would never bring our children to a day care centre where there was only one person watching 20 six-month olds. So, inherent in institutional care is a whole range of forms of deprivation. There's sensory deprivation. Often these children lie in a room staring at a white ceiling and white walls for the first 12 months of life. There's linguistic deprivation. There's no one talking to them. There's cognitive deprivation. There's no one stimulating them. And very importantly, there's social and emotional deprivation. There's no one really loving them.

So we were interested in looking at the effects of early institutionalization on early brain and behavioral development. But as importantly since we anticipated that this would lead to negative events, that is, behavioral and brain development would not be optimal by being raised in institutional care we were interested in whether we could develop an intervention. So in this project, which is being done with my colleagues Charlie Zina, who's a child psychiatrist at Tulane University in New Orleans and Nathan Fox who's a developmental psychologist at the University of Maryland in the United States, we designed a study that worked as follows.

We looked at a sample of about 150 or so children who were abandoned at birth and placed in various orphanages in Bucharest, Romania and then we had a second sample of children who were being reared at home with their biological families in the greater Bucharest community. After we did a very extensive baseline assessment we measured cognitive development, social/emotional functioning, linguistic development, physical growth and development, brain function, etc. etc.

After we did the initial baseline assessment, half of the children who had been placed in the institution were then placed in foster care that we created. And these were randomly placed children. So we didn't pick them we just randomly assigned them. And the reason we could do that, because it raises in your mind some ethical questions about which child goes to foster care and which does not, is that foster care did not really exist in Bucharest at this time. Moreover, this is a country that, for many years, has a history of abandoning children, not taking them in as foster children. So it was very challenging but we eventually identified about 70 or so families willing to take kids in and we could then pay for those placements.

So the study is longitudinal, meaning that we're planning to study these children for several years, probably about four years, or there abouts. And what we're then looking at is the development of the children who are initially placed in the orphanage or the institution and now are placed in foster care relative to the kids who are placed in the institution and stay in the institution and then relative to the comparison group of kids who live at home with their parents.

So far we've been able to look somewhat exhaustedly at our baseline data and we're now just beginning to look at our foster care date. And the baseline data do show, in fact, very, very negative consequences to this rearing environment. So an example is that for measures of intelligence, broadly defined because it's hard to measure intelligence in a one-year old, but using a developmental test, if our community sample had scores of about 100 on that test our institutionalized sample was scoring at about 65. On measures of language development and on physical growth and development, the children in the institution are very, very behind in all of those respects. When it comes to social/emotional development one of the things we're looking at is attachment behavior, and that's the relationship an infant or a young child has with his or her primary care giver. We're finding that a great many of these children have disturbances in attachment; whether they've failed to develop an attachment or the attachment they've developed isn't as healthy as we'd like to see. So of course now the big question is what are we seeing among those children we've placed in foster care? And we're just beginning to look at those data but we find a dramatic improvement in physical growth and development, a dramatic improvement in language, so their language starts to take off.

We find that there's only a very modest change in their cognitive functioning but that may be because the children have only been in foster care a few months. The most intriguing finding is that if we can look at the EEG of the children in the institution versus those in the community sample there are dramatic differences. So, using my hand, if this is the normal EEG, this is the EEG of the children in the institution. It's a fraction of what we see in the community sample.

After a minimum of three months in foster care we're starting to see that EEG normalize and look a little bit more like the kids in the community sample. And as our children get further along in the study we hope to continue to follow them until, on average, they're about four to five, when they finally finish the study.

Nelson – face recognition (3:12)

Let me first talk a little bit about the work we've done on face recognition. The first question we should ask is so why would you want to understand how the ability to recognize faces develops? Prior to the time when infants develop language most communication is non-verbal. So that means really the first one to two years of life a lot of communication between a baby and his or her primary care giver or anyone else is non-verbal. So we need to understand how it is babies read faces, both at the superficial level of "who is that?" to the more fine level such as "how does that person feel right now?" And so we put a lot of effort into understanding that development as well as what are the neural systems, that is, what are the parts of the brain that are developing that facilitate those abilities to recognize faces and facial expressions of emotion.

The other part to it is to understand how experience influences that process. Some people think that this is such a fundamental ability that there's an area of the brain dedicated to recognizing faces and it's there at birth. We take a different view which is that we think that there's an area of the brain that has the potential to become specialized for recognizing faces. But it's only by seeing faces that that actually happens. And very good evidence for that actually doesn't come from this lab but it comes from Daphne Marro's lab at McMaster University. Daphne Marro and her colleagues have looked at a sample of children who were born with dense cataracts. These are opacities over the eye and at a certain age, usually a few months after birth, have the cataracts removed. And as a rule, they have a wonderful outcome. Their visual acuity improves dramatically, they see quite well. But it does turn out they still show subtle deficits in recognizing faces.

So those data, coupled with our own data where we record brain activity, collectively says that experience really does thrive that ability. And I'll give you an example. In the paper two former students of mine published last year, Michelle DeHawn, who was going to McMaster as an undergraduate and then came here to graduate school and now is --- University College, London and Olivia Pascales who is from France but now works in England and did part of his dissertation here, showed that, predicted rather, that early in development infants have a very broadly tuned perceptual apparatus for recognizing faces. So what that means is that they should be quite good at recognizing and discriminating all sorts of faces but as they get more experienced with just human faces they would lose that ability.

So we predicted that babies would, young babies would be as good at discriminating two monkey faces as they would human faces. Now anyone who has seen monkeys, unless you work with monkeys, know that they all look alike. And at six months, they found six-month olds were as good at discriminating two monkeys as they were two humans. But by nine months they were like adults. They could not do two monkey faces anymore. And so the logic behind that is that's because by nine months infants have had three months more experience seeing human faces and they are gradually losing the ability to discriminate monkey faces. So that's another way to demonstrate that experience is important.

Nelson – gene expression (1:17)

We all know we have genes. The Human Genome Project has now revealed that humans have about 30,000 genes in their genome that is their constellation of genes. Many people think that genes are just static, but in fact, genes turn on and turn off at different points in development. A classic example of course would be puberty. The genes that regulate pubertal development don't get expressed until 10, 11, 12 years of age. There are some genes that get turned on at one point and turned off at another. But then there is an interesting phenomenon where gene expression, that is, how a gene reveals itself is influenced by experience. So we do know that if, for example, you experience a very stressful situation, I don't mean a test, but something very, very stressful - loss of a parent or something like that, in that immediate period there'll be a set of genes that will express proteins that will in turn affect brain function. And that's another way to think of gene expression. So by expression I mean at one level, at the molecular level the expression of proteins, at another level they express themselves in changes in behavior we refer to that as the phenotype, the behavioral expression of the gene.

Nelson – how experience and biology interact (1:50)

So there are many ways to illustrate how experience and biology interact. Here's a few examples. Children who are again born with cataracts and are deprived of seeing the world normally... those cataracts or if for example they don't have cataracts, they're cross-eyed; if those two things aren't corrected their vision will not develop normally. And the reason is that their visual system needs to be driven by experience. Language would be another example. We know that in the first six or 12 months infants throughout the world can discriminate virtually every speech sound in any language. So a Canadian baby can discriminate English, Thai, Czech, Japanese and the like and Janet Werker of UBC has shown that as kids get to be a little beyond a year they start to lose that ability and they're better at discriminating the sounds from the language they're exposed to. Much like the example I gave earlier with faces and monkey faces. Initially a baby can discriminate monkey faces and human faces but as they get older when they've never seen monkey faces they can only do human faces. So that's another example of how experience influences the brain. It's unfortunate that we have sometimes have tried to apportion variance which is a fancy way of saying how much of behavior is genetic and how much of it is experience when we know that the experiences we have on a day-to-day basis weave themselves into the brain, which changes the brain, and changes how the brain functions. So it's an iterative process. And that is something that begins at birth and continues throughout life. Learning and memory is the best example of that of course, something we do throughout our lives, where the fact that we can acquire new information and learn about the world is the way our brain has been changed.

Nelson – learning difficulties (3:53)

We've been focusing on one aspect of face recognition for a number of years that specifically is concerned with how babies develop the ability to recognize facial expressions of emotion. And I should add that the way I got interested in this was working with children in Camp Towe, which is in Haliburton, Ontario, who had learning disabilities. And what occurs commonly among many children with learning disabilities are these sort of deficits in social communication. They sometimes just don't know how to read a facial expression to know what you're feeling. And so from that I sort of developed an interest in trying to understand what the ontogeny would be of that ability. That is, its origins. And so we've been looking at from the time when kids are just a few months of age and we wait a few months because their vision isn't very good and this requires fairly good vision to look at subtle changes in the face, through about four or five years, changes in the child's ability to recognize different facial expressions.

What factors influence that. So an example of the latter is that in our Bucharest early intervention project we're looking at emotion recognition in our institutionalized children because we think that the areas of the brain that we know are involved in recognizing emotion, the medulla would be one, which is again a structure deep in the brain very near the hippocampus in the middle, someplace in here, and another area called the orbital frontal cortex, which basically, if I can put this back together, is in the frontal lobe, right behind your eye, so right behind here. Those are the areas that we know are critically involved in recognizing facial expressions.

We think those areas may have gone awry, based on these early institutionalized experiences and that these children might not show typical developmental profiles in recognizing emotion. Now actually we're showing that they are pretty normal in that respect. It may simply be that we haven't looked at them long enough, that is, these are babies who are only a year or a year-and-a-half. It may be that by the time they're four or five they'll show differences, but right now they seem to be ok. So the focus there is to chart the development of this, and one of the things we've observed is that babies are very good at discriminating happy from any other facial expression. They can do that by the time they're a couple of weeks old. But they're not very good at discriminating negative expressions like fear from angry until they're well past a year of age. The other surprising thing is that, for babies anyway, if you give them a choice between looking at fear and happy, or fear and anything, they always look more at fear. They're never upset by it, they just prefer it. We think that's important because fear is a very important emotion.

And so we think they have this sort of built-in apparatus that makes them gravitate to fear because it sends a signal that there could be danger in this situation. So again, probably when they get older they would be upset by it, possibly, but when they're younger they just look more at it. And because of that, sometimes they don't show evidence of discriminating fear from another expression because they're so glued to fear they're not even looking at the other expression.

So that's one of the interesting observations we've made as we've gone along. And of course, again, the implications for this have to do with kids with learning disabilities, children with neurodevelopmental problems like autism or Williams syndrome, which are genetic disorders in some respects, where we know that these children show deficits

sometimes in recognizing facial expressions. What's particularly problematic for kids with autism is that if language is also delayed, then they can't communicate very well linguistically and that means they also can't communicate very well non-verbally. So that gives them a real deficit in social communication.

Nelson – MRI results (1:55)

The last two findings in the project right now that are more biological is we did MRIs on all of our kids and we also measure what's called telomere length and I'll come back to that in a moment. The reason we looked at the MRIs is that we noticed our children has smaller heads and that they had underpowered brain activity that is they had less EEG activity. Well sure enough now that we've done MRIs on them we find the children in the institution have less grey matter; grey matter refers to the cell bodies, and less white matter, which means the parts of the brain that have myelin associated with them, so there's a dramatic reduction in both and that means their total brain volume is reduced, so they have smaller brains which accounts for smaller heads and underpowered brain activity.

The kids we put in foster care show no difference in grey matter; the grey matter's not changing, but they are showing an increase in white matter which is good, and that probably accounts for the normalization of the EEG we also see. Now telomere refers to the cap of a chromosome and it protects the chromosome through the thousands and thousands of cell divisions all cells undergo, except the brain, throughout the lifespan. So when you cut yourself your cell repairs itself. So the telomere region is designed to protect the cell through all those divisions it's going to undergo, but it's also a region that's very sensitive to oxidative stress and the like. We find that children in the institutional group actually have shortened telomeres. So we're showing a biological toll of this early adversity that it is the telomere region gets shorter and the reason that's so important is the telomere region can only shrink so much before the cell will stop dividing and the cell dies. So we think there are going to be long term health consequences for this as well.

Nelson – Nelson's lab (3:30)

There are several segments in this CD. The first segment is entitled Voice Recognition and here what you're looking at is our testing of the newborn's ability to discriminate mother's voice from a stranger's voice. So in the beginning what we're doing is putting on electrodes, put on the baby's head and then we place a small ear insert into the baby's ear while the baby is in a light state of sleep. And then what the baby hears is their mother or a stranger saying a simple word like 'hi baby'. So they hear 'hi baby' by mom and 'hi baby' by a stranger. And we present this about 100 times, maybe 50 times each and that entire time we're recording the baby's brain activity. And in one segment of the CD you can see on a blue screen the baby's brain activity going up and down like that. And the goal of that work is not just to look at what are the neural systems involved in recognizing mom's voice, but as well we're looking at a clinical population of babies who we think have had damage to the part of the brain involved in memory who may not have benefited from the experience of hearing their mother's voice and therefore may not recognize their mother's voice at birth.

Now in the next segment which is called Face Recognition. What you see us doing there something comparable to what we saw in the newborn. This is a 6-month-old baby. We place a net of electrodes on the baby's head and then what we're doing is showing the baby pictures of faces and we want to know can they recognize a face they've seen before from a novel face. And so again we're recording brain activity and again on the screen you can see a picture of the baby's EEG. And the goal of that work is to look at the neuro correlates involved in discriminating one phase from another phase.

This is an older child. This is a 4-year-old entitled Emotion Recognition. Again we're recording brain activity except this time we're showing the child different pictures of facial expressions and we want to know, a. does their brain activity show that they can discriminate one expression from another, and b. does their brain show unique patterns of brain activity to some expressions rather than others. For example in some of our earlier work we demonstrated that anger expressions show a particular aspect of changes in brain activity that we don't see with other facial emotions. So the goal of that work is to look at the neuro correlates of recognizing emotion.

And finally in the last segment entitled FMRI we're showing how we actually conduct functional magnetic resonance imaging studies. This is an 8-year-old child where she's brought into the scanner room and you can see what the tunnel looks like, the scanner. She hops up on the bed which goes up and then the child slides into the tunnel and then she's given a button box and what happens is that on the screen in front of her we're showing different patterns and she has to push a button that corresponds to which pattern she's seen before and which is novel. And so all she's doing is pushing a button that corresponds to whether she's seen one of those patterns before and which one she hasn't seen before. And during that entire time we're taking very detailed pictures of her brain. So we'll know precisely what part of the brain was involved in performing our task. And that whole test will take about 20 minutes.

Nelson – neural development and life-long plasticity (13:14)

What we want to be able to account for is how is it that when sperm and egg unite to give rise zygote, it eventually gives rise to something as complicated as the human brain and this is a multi-dimensional view of what the brain looks like in the adult in all it's various configurations. So what I'm going to do is start with going through some of the stages of brain development and having established that then turn to what it is that we know about the role of experience and influence in brain development. So just briefly I will summarize in outline form and then describe each in detail the various stages.

The neuralation essentially refers to the construction of the neural tube. Some of you will know that errors in neuralation lead to neural 2 defects. Spina bifida is an example of that. Once the tube is formed there's a stage of proliferation where immature cells are being produced on a huge scale.

Cell migration refers to the actual construction of the cortex where cells, these primitive cells migrate in an outward fashion and basically build the brain. Differentiation means once the cells have gone to their correct location the analogy being you take the subway or the tube from one stop to another and when you get off at that stop you mature. And that's the process of differentiation. Some of you have that experience I'm sure. The now mature neurons set up shop, they form connections between one another. This is synaptogenesis. And the last stage of brain development is myelination, which is simply the laying down of myelin on certain axons in the brain to speed up information.

So let me go back to the first stage of neuralation. Right after conception, between the 18th and the 24th day after conception the embryo is divided into three layers, an inner layer, middle layer and an outer layer. And the outer layer, the ectoderm of the embryo begins to thicken and form a pear-shaped neural plate and I'll illustrate this in just a moment. And on that plate a groove starts to form down a longitudinal axis and gradually the groove deepens so a tube forms and the tube then closes up at the bottom and top ends and the part at the top end will become the top of your head. Your brain here and the bottom end will become the bottom of your spinal cord.

So this is an electro micrograph that illustrates this. On your right you will see from top to bottom the plate thickening and a groove forming and then the groove deepens and then now the groove has become a tube and then the tube seals up at both ends. This is a cartoon version of this. So once that's happened what you see on your right is what says forebrain, midbrain and hindbrain. And so those areas differentiate out to give rise to… fore brain would be basically your neocortex, mid brain would be structures down one step below that involved in various autonomic functions and then the hind brain and the rest of this becomes your spinal cord. Now what's essential about this is this is occurring very, very early in pre-natal life. It's essentially done by about the 24th pre-natal day and as I tell my undergraduates when I lecture on this, many women have no idea they are even pregnant at this point in time. And we know from epidemiological studies now that some forms of neural tube. Defects have been tied to deficiencies of folic acid and in fact now in the United States folic acid is routinely given. There has been a drop in the neural tube defects. So once your neural tube forms, neurogenesis is this next stage.

So now we have immature neurons and immature glial cells. Glial cells are the other major form of brain cell in the brain. In most regions of the brain neurogenesis is complete prenatally. That is we assume that the newborn brain has all the cells it's ever going to have. Thus unlike scratching yourself or getting a bad sunburn when you repair yourself, if you damage a brain cell you don't make a new brain cell, which is very unfortunate. However there is very recent work now that starts to question the notion that neurogenesis is completely complete at birth. And in fact over the last several years using some very methods in neuroscience it's been discovered that in some regions of the brain, notably the hippocampus there is a process of post natal neurogenesis that goes on through at least midlife. And so we are essentially creating new neurons throughout mid life. Somebody may have this feeling, a little pop in your head; it's probably a new neuron that was being made. And most importantly we know that this post natal neurogenesis can be up regulated or down regulated by experience, meaning that in a learning environment there's an increase in the production of new cells. In an environment that's highly stressful there's a decrease in the production of these new cells. Once you have these cells we have this process of cell migration.

So the neural tube is closed, there is this proliferation of cells that lines the neural tube and then some of the cells get connected to one another and they climb along a fiber to another location. We have six layers of our cortex. The cortex is just that thin layer with convolutions in it and the way it gets constructed is that a cell will migrate what's called a radial glial fiber to its target destination.

So to go back to the subway analogy, you get on it at Bloor St. and you know you have to make three stops and you get off there. And once you get off is once again, as I said before, mature. The cortex forms in an inside out fashion meaning the earliest formed layers are formed first and each subsequent layer is formed by cells moving past that layer to the next layer. So we have not only 6 lamina but we have columns of related cells by virtue of this process. And so the next slide illustrates this as well.

So you can see here, if you look at the left side where it says subventricular zone at the bottom, this would be the point of origin of some types of cells. The long blues lines are the radial glial fibers and what you see as the yellow part is the cell attaching to a radial glial fiber and traveling up. And typical migration time is about 21 hours. Now the next slide is going to illustrate this in real time.

What you're looking at here, this is a video of migration in the ferret brain. And what you're looking at here is this cell, moving at a non radial direction, moving away. Now to go back to something Dr. Rutter said, what's important about this is that the point of origin of this primitive cell determines in part where the cell will wind up in the cortex. But Susan McConnell whose data these are has elegantly shown that if at a certain point in development you transplant the cell to a different location in the subventricular zone it will actually wind up going to a different part of the cortex and being a perfectly normal cell. But if you wait too long you can't do that. So even at this early point in development we have a strong genetic propensity for cells to move in a certain direction, but that genetic propensity in fact can be influenced by experience.

So we have a plastic process, very, very early in life; between roughly the 12th and the 24th week. So most cells migrate by the end of the 25th week prenatally. At this point in time the cells have not differentiated, meaning that they have not matured. So it's a little tiny cell; it hasn't yet developed a cell body or axons or dendrites, which means it's very small. The reason our brains are convoluted, have that pattern to it is that the brain grows over onto itself.

This is what the brain looks like at about 23 to 24 weeks gestation. Notice that there really are no sulci and gyra in this brain and some of you will also know that babies are now being delivered at this age. So those of you who spent time in an intensive care unit know that a baby delivered at 23, 24 weeks essentially has a brain that looks like this. I won't belabor that.

So once the cells reach their target destination several things can happen. The cell body can develop, the cell can die, which is referred to as apoptosis and that's a perfectly normal developmental process. At least 50% of all the cells that are original born wind up dying. Processes like axons and dendrites can develop and then synapses can form and this is what goes on during the latter stages.

So this is a brief cartoon of what a synapse would look like <voiceover> ".the action potential, red dots propagate along the axon of neuron 2, leading to an excitatory post synaptic potential in the target zone. The depolarization spreads passively within the target cell until it reaches the axon hillock. Since the depolarization is lower than the excitation threshold an action potential is not generated and resting potential is resumed. Success of activation of neurons 2 at short intervals brings to summation of the excitation in the target cell a process known as temporal summation. If at a given moment the depolarization at the axon hillock exceeds the excitation threshold an action potential is generated."

So that was just to illustrate how this would work in a real brain; how a synapse would connect and cause an action potential to occur.

So let me briefly get through synapses. There's massive over production of synapses and so the newborn brain has many, many more synapses than the adult brain. So over production is followed by a period of retraction in which now we cull back of synapses to adult levels. In the human this rate of retraction varies from area to area. For example in the visual cortex the peak of over production occurs between the 3rd and 4th post natal month, and by about 4, 5, 6 years of age there's a retraction to adult levels of synapses.

In contrast synapses in the middle, frontal gyrus in the frontal cortex peak at around a year of age and are not retracted to adult levels until mid to late adolescence. So here's a slide that illustrates that. So the solid line are synapses in the visual cortex, the dash line are synapses in the frontal cortex. And what you can see is the peak occurs much earlier in visual cortex and then the retraction is over by about four or five years. And in contrast middle frontal cortex is a much later period of retraction.

So why do we over produce synapses? This is Monday morning quarterbacking, we don't really know, but this is our best speculation. Captures experience thereby pruning or cultivating synapses. It can be adaptive for the organism; a period of opportunity; it can also be maladaptive or a period of vulnerability depending on the nature of the experience. And thus plasticity can be thought of as cutting both ways.

And finally myelin is a lipid protein substance that is produced depending if you're in the autonomic or peripheral or central nervous system, wraps itself around an axon, speeds up the conduction of a nervous impulse along that axon that has implications for serial and parallel processing. It occurs in ways beginning in the last part of gestation, in the full term pregnancy. The next wave occurs in the first months or year or so post natal life, and the final wave which largely affects the hippocampus and the frontal cortex…when I do this I'm trying to point at the hippocampus and the frontal cortex...as late as middle age. In fact Francine Dennis at Harvard has demonstrated continual myelination in the hippocampus as late as midlife. When you go back to what I said about post natal neurogenesis it is no accident then that we're continuing to make new cells in the hippocampus and new cells seem to be being myelinated. What Francine has not demonstrated is whether the cells that are being myelinated are 45 years old or 4 days old, and that's an impossible thing to tell at this point with technology.

The summary of functional brain development; most aspects of language and memory are established fairly early in life. However prefrontal functions, cognitive flexibility, working memory and things like that have a much later developmental trajectory. We know that these are functions that are typically not obtained until mid to late adolescence and anyone who know teenagers recognize this. In fact some of you may wonder will it ever happen. But it typically does and these are then fine tuned much later on. Those of you who teach undergraduates know that even some undergraduates still suffer from difficulties in some of these areas, like planning behavior. But then as you get to be older you do this better because you have to plan your behavior because otherwise you would never remember what you were going to do. This is an overview of human brain development. This is a slide that I made for a book that was published by the National Academy of Sciences last year, Neurons to Neighborhood, and in brief you can see, if you just look at the timeline it underscores the point that Dr. Rutter made. It is naïve to think that brain development ends at the age of three or even five because

Nelson – research tools (3:20)

We use a number of tools in my lab to study brain development in infants and human children. When children are less than five or six years of age we primarily focus on recording the brain's electrical activity. And the way we do that is we place little sensing devices over the surface of the scalp. We can do that with a little cap or a net. And essentially what we're doing is recording the electrical activity that occurs between each neighboring neuron or brain cell, that then moves or propagates to the scalp surface where we place these sensors. And that tells us something about the moment by moment transactions that are going on in the brain during the time a baby or a young child is thinking. Now when children reach the age of five or six, we can also start to do magnetic resonance image scanning on them, specifically functional magnetic resonance imaging. And the reason we have to wait is simply that kids are too prone to wiggling around before they're five or six. Even five or six is pushing it sometimes.

So here the child lies in a tunnel. Many people have seen what these MRI scanners look like. And while they're in this tunnel we're presenting pictures or sounds to them and we're asking them to do something, such as show us what they remember by pushing a button. The only constraint is that you have to lie very, very still. We can't tolerate more than a millimetre of movement. So a younger child, even though they think they're sitting still or lying still, in fact is probably moving a little bit. So in our experience, once kids get to be around six, they're more likely to be able to sit still for ten or fifteen minutes at a time. Actually testing children in this is much easier than testing adults. Children as a rule are never claustrophobic, they kind of like being in that. If you go to playgrounds nowadays, you'll notice there are lots of little narrow tunnels that the kids play in. So they're kind of used to that.

Niles – curriculum (1:06)

And so one of the first lessons that I often teach students about when we talk about early childhood education with tribal community is that all of us have to do a reflection of who we are and what we bring, and be willing to listen. Ultimately those qualities should be considered, in my opinion, 'best practice'. And it's not the idea of a certain curriculum fitting each community. The fact of the matter is if I were to go to the Hopi tribe and say 'let's develop a curriculum for Hopi kids, I couldn't use that curriculum for Navajo children, nor should I. So the heterogeneity of the communities also makes things a lot more complex than a lot of times people are interested in working through because we want an easy answer. But when it comes to these types of communities, I often find that the best place to start in communities is be really talking about what it means to be a community member and how that would relate to early childhood programs.

Niles – language nests (1:27)

One of the most successful rural projects that indigenous early childhood educators have, are something that they took from the New Zealand Maori people who say, 'you know what, language is really important, and in fact, it's so important to us we're going to create', what they call 'language nests'. Those language nests are Elders and parents who teach the language to these young children, but they do more than that because that's important but they also relate it to the concepts that they're trying to learn, in the text books and everything else. So for example, if a person were to say, 'we're learning about math in early childhood', usually when I, when the dominant world thinks of math we think of things like numbers, or we think of things like cheque books, or anything along those lines.

But in indigenous communities, with language nests, the actual words 'this is math', that's not a word in many indigenous languages. So it's more about developing concepts that make sense in that environment. So they might use something like 'ghost beads' to count. Or bead chains to count. Social studies, or mathematics or geometry. Or, they might also, there's a big push these days for multiple intelligence, meaning social-emotional, cognitive etcetera. They might also use some of the historical icons to frame social-emotional development.

Nurani – integrating Care for Child Development (3:06)

We introduced the Care for Child Development in 2013 and we started off with a master training. So we had 13 people from East Africa and a team from also Mali and Central Asia that had come in. And it was a two-week training and we, the target group was really ECD teachers or ECD professionals. It was health workers so we had staff that are involved in AKF's health programs. We had a nurse from the Aga Khan University School of Nursing and Midwifery. We had a doctor, a pediatrician. So we had a good range of sort of professionals from the education and health sector. And we did the basic training and then a training of trainers so over a two week period and it included sort of mix between the clinical component and then the theory. Now all these trained personnel then went out and integrated it in to their workplace and it's very interesting. So the Madrasa team went back to their programs and now actually this really forged strong partnerships with the health sector because the delivery mechanism of the care for child development is through the health infrastructure, we now had forging of partnerships with health facilities and health workers so there was training. The master trainers now trained community health workers but also the ECD teachers in the Madrasas so you had the combination of the two. So you now had a partnership with the health facilities so strengthening the integration of health and nutrition in to the Madrasas, so that linkage there.
The health team went out in to their health programs and trained community health workers. And so although having a stronger focus on the health side, we also built in the nutrition component. And in the areas that we work in Kenya, in Tanzania, we work in areas that have very high levels of stunting. So we also have been working on what is known as the Positive Deviance/Hearth approach. It's an intervention to really address malnutrition in young children, so malnourished children. It's a form of rehabilitation, a two week period where families that are doing very well that have children that have good nutrition outcomes are linked with families that have children that are malnourished. And over the two week period they stay together and they learn the practices of both the families. So they learn about the nutritional, the hygiene practices but what we did is we also integrated in the Care for Child Development. So it's also the integrating on ECD knowledge and understanding. So the idea is after the two week period those young children are supposed to gain about 400 grams. If they gain over 400 grams over the two week period, they have been successfully rehabilitated. And then there's a 21-day of just reinforcement of messages. So the health program in southern Tanzania and in Coast Kenya both use that mechanism. And it's really, it's a methodology to build resilience in communities.

Nurani – positive deviance initiative (3:49)

The idea behind the PD/Hearth is that you have families that live within the same context. They essentially are the same socio-economic status. They live in the same environment. They have access to the same resources. They're living in the same climate, so the same climatic conditions. So they have access to the same sort of vegetables and foods around them. And they're probably in similar sort of work environments. They could be in agriculture or small business. But the issue here is that you have one family that has positive practices. They probably have good handwashing practices, good hygiene practices. They've understood better the importance you know at what points you need to wash your hands and feet. They've understood better the variety of foods are available at that particular time in the year and that season, what kind of food is available. They may be growing that kind of particular plant or fruit or vegetable. So they have created an environment for themselves. They've probably better understood you know, sort of maybe they're playing and reading to their children a bit more. So they have certain practices that have been much more enabling and positive that would allow them to grow their children healthy.

Now this other neighbouring family you know, it could be for various reasons but is just not picked up on understanding that you can grow certain types of vegetables or just not understood that there's seasonal variation to think through. You know it's this particular season, I can grow this vegetable or this fruit. Or you know at what points I need to wash my hand or just probably not understood the importance of interacting with their child, talking to their child. You know there is a lot of traditional beliefs. There's messages that come from a grandmother or a family or relative. So when you have the PD/Hearth and you put these families together, it's a family that's doing well is actually showing by demonstrating on a day to day basis that it's you know, it's this particular season, I've grown this particular plants and fruit. This is how I've saved up you know for fuel or for wood to light my fire, to have porridge or to cook some particular vegetables and it's very possible. It's very much within the context you know, of what's available and what's affordable. And so the other family's actually picking up and learning that yes, you know I have the same circumstance that you do. I have the same constraints as you do but I see what you've done with your environment. And so it's learning from that.

Now the intermediary in here is the community health worker who has been trained, who has had a basic training on maternal, newborn, child health, on hygiene, on food practices, on the care for child development. So this person is also facilitating the dialogue that happens. And so there's that two week period where there's this intense learning. They come up with a menu, a menu item for that 14-day period. So it's different foods but it's based on what's available, so they're learning different food items as well. They could very well leave this 14-day session with full menu items of what they can you know, cook over that 14; during that period in time. So they go with you know, concrete lessons and with just having the knowledge of what they can do and then the practices. And then what happens after that 14-day period, the community health worker goes in there to keep reinforcing the messages. Remember you learned that. Remember you had to wash your hands after cooking, after cleaning your child and remember you had to do that. Remember that can grow this particular food during this season. So it's that reinforcement. And they say that through the PD/Hearth a 21-day of reinforcement of messages, concretizes it and you do see behaviour change.

Ogwari – context matters (2:33)

I think it's important to have a research from the population due to contextual validity. If we don't go to those specific communities then we can as well give a treatment that may turn out to be fatal instead of helping. So the contextual validity comes in and it's key that we diversify as much as possible and try to reach even the rural settings, the places that are very far from the facilities that we need like the health facilities, the educational facilities so that we have the representativeness of the population. And whatever we come up with can therefore be valid. And you know, what does the community value? As we go out to different contexts then we'll find out what the communities value.

And we may even find out that there are certain things that they know that are very good in child growth and development. And they can be encouraged to have such practices. I want to have one example, like the baby carrying that goes on in Africa. Africans carry babies on their backs. I think it has many functions. One, makes the mother easy to walk around but even as the mother walks around the mother can talk to the child and as the mother talks or the caregiver talks to the child what happens? The language development occurs. And when the child is carried on the back and he sticks out his neck, he's able to see from far. Therefore, that child is able to learn more. And the attachment that develops as we know the attachment theory that Ainsworth developed and she talked of the sensitivity, responsivity, attachment theory. So when the mother is quite close to the child, then it means the attachment comes in and the child will develop secure attachment. So going to different contexts, there are things that are good. The good practices can be encouraged. The bad ones they can be, they can be stopped. But as well we can come up with interventions that are, the interventions that are valid and they're helpful to the varied society instead of having generalized knowledge and applying it to different contexts.

Ogwari – extended family systems (2:04)

The extended family system that we have in the African context as well cushions the child against the negative interactions that may occur within the family. And you know, when you ask these children, I want to give a direct translation here, if you talk about a father in the rural setting they know a father is, all the uncles are called fathers and that makes the meaning even bland. And when you talk of mom, all the aunts are called mom. Now although the boundaries are not clear but it has an advantage – it cushions the child against possible negative interactions that can be existing within the nuclear family. Therefore, the child has somebody else that he can develop or she can develop attachment to and explain her problems. So that was something funny that the father, then they ask you, my small father, you know, even the parents they ask you, they talk of the young father, the older father and the mothers are also like that. So that is a strength. That's a strength that should be built on, that where the extended family can still exist, let them go on with the shared responsibility of bringing up the children because we are a collectivistic society and in collectivistic society the bringing up a child is a shared responsibility. So the aunts, the father, the uncle, the siblings and even the neighbours participate in this. That is a strength that can be built from the rural set up. It may be disintegrating in the urban setting because of the set up. You don't have your relatives around. But I believe that where it can be practiced it is still a good idea.

Pelletier – inquiry in early childhood education (2:15)

How I see inquiry, to me inquiry in early childhood is truly based on natural curiosity. It's systematic in some ways because educators learn or know implicitly how to have children ask questions and reflect on those questions. So it's not simply asking questions and going with children's ideas, it's also having children come back to that and taking their questions and their explorations as the object of learning, and so that reflection is very important. Another piece that I think is important in the inquiry program is language. So, there's a kind of language that speaks about thinking and knowing and guessing, and it's okay to not know something, but that as you continue to ask questions and you work together with your colleagues and your educators, that evidence begins to inform whether you know something. So I think inquiry is part of play. It certainly happens in a play based program, but at the same time I think it's more explicit and it's controlled a little bit more by the educators in terms of helping children to learn to build on their questions, keep asking questions, reflect on what they're doing, and then document their learning as they go along.

I think documentation provides the physical evidence of what the questions and what the explorations have been. So it gives children something concrete to examine and to think about. And of course that can change over time so children actually have a concrete maybe series, a panel of photographs for instance that help them to see how their questions and how their exploration has developed, and it gives them something really observable to think about.

Pelletier – learning to print (2:14)

So after children have been playing games at home and at school and in child care, such as finding things around the room that begin with the sound or the letter ‘s’, they start to become interested in creating something in print themselves because they are seeing print all around them. And most children have a curiosity about, they want to pick up a pencil and make a mark on a page. And with very little prompting from adults, they will begin to do this kind of thing. What I do in my research is I ask them to write certain things because I’m interested in what they think print is, and how they move from a pre-literate understanding of print to a literate understanding of print .

So I might ask them to write ”Daddy has three hockey sticks”. That;’s one item from the test that I give them. “Daddy has three hockey sticks.” And I’m interested to know, are they going to represent “daddy” somehow. Are they going to represent the “three” somehow. Are they going to represent the hockey stick somehow. And how does that change as children begin to acquire the alphabetic principle. And sure enough, you see that they tend to draw a typical four-year-old representation of that would be some kind of form for “daddy”, it could be a “d’ or it could be a head, and the “three” might be represented both by the numeral and again by three objects.

And as they acquire the alphabetic principle, they tend not to do this redundant writing anymore and they begin to use a “d” for “daddy”, maybe two “d’s”. They will start to include the “has” the word “has” which wasn’t important before but now it is. And they might represent the “three” by the numeral or they might try to write out the whole word. And then “hockey sticks” they will try to sound out as opposed to drawing three objects. So I’m very interested in how they make that journey and how interesting and clever their errors are.

Pelletier – learning to read games (3:30)

It's true that virtually all children learn to speak without being explicitly taught. how to speak. But most children do not learn how to read without some form of instruction in how to read. And that's because the written language doesn't map perfectly onto the spoken language. And thus children, many children, most children, need help in learning just how do you map written language onto oral language, or oral onto written language. So this tends to involve at least some type of experience in phonological training.

And it doesn't mean that you have to sit with children with work sheets and have them trace letters and use flashcards. It means that children should learn through very natural ways how to parse words. For instance, can they hear the sounds within a word. So can they say "baseball" without the word "ball", without the sound "ball"? So that's how you begin these kinds of games. Just fun things like that. And eventually you can start moving down to the level of the letter itself. So, "say a word without a particular sound on the end". So, or changing the first or last letter of a word. So, "say 'rat' but say it with the /b/at the beginning". (I didn't say that correctly but…) Or "can you say 'bat ' without the /b/ sound?"
So learning to segment words, and learning to segment sounds within words, that is just strict oral phonological training, and that's very important. It's the first piece. It just happens in talk, it happens in games, it happens through rhyming. You can play clapping games with children too so that, you know they can hear the number of sounds in a word. So many people would say that there is only one sound in the word "cat". But no there are actually three sounds in the word "cat": /k/ /a/ /t/. And so this is the kind of fun training that we can do with children to help them pay attention to sounds in words.

So that's one piece that they need to have. And another piece, at least in alphabetic cultures is to know the names of the alphabet. So they need to know the letter names and they need to know the sounds that those letters make. And this can all be done in enjoyable activities, in schools, in child care and in homes. Gradually they learn to recognize the letter itself, and in a natural context. So this is where environmental print is so important and parents just pointing out things. The famous golden arches I guess, that's one example of environmental print. But other things would be just the sounds and words around the house. So put the child's name on his or her bedroom door. And the child just becomes familiar with print as a symbol of something else.

Pelletier – play-based program (2:54)

I see a play based program as one that capitalizes on children's natural curiosity, natural need to play. To engage in active exploration or maybe just fantasy play, but it capitalizes on what children do naturally. Good educators recognize that children need to play, and they set up environments that facilitate it. Play takes many forms. Play can be active outdoor play and some children will describe play in that way. They see play as climbing on the climber, chasing friends, that kind of thing. Other children will describe play in different ways, like playing in a dramatic play centre where they're taking on roles and engaging in pretend play. Other children describe it as talking with their friends. So play takes different forms for different children, and all forms of play are important.

Increasingly we're seeing the real value of complex socio-dramatic play in terms of fostering children's ability to regulate not only their behaviour but their emotions and their language, because in order to engage in this complex socio-dramatic play, they need to take the perspective of the other. They need to remember who is playing what role. They need to maintain the language that's going to be of interest to their friends. And so good teachers will set up opportunities for children to engage in that kind of play. I think it's also important to think about what children want or expect in say a full day kindergarten early childhood setting. Really, when they come into kindergarten, they're big kids, and they might think that this is a time for them to do some work. So it's not that they're engaged in pretend play from morning until evening, it's that teachers capitalize on their need to play, but they also know to infuse some sort of instruction whether it be paying attention to sounds, phonological awareness, but these can be done in enjoyable ways. It doesn't have to be sitting down with pencil and paper and tracing and that kind of thing.

So I really see play as being something that's intentional on the part of the educators. That recognizes individual children's understanding and need for play, and that sets up environments in which that can happen, and that teachers and early childhood educators know how to base their assessment on what children are learning in play.

Pelletier – the educator's approach to inquiry (3:36)

I think there is a stance toward teaching early childhood education that comes more naturally for some than for others, but there is a piece of trust and a piece of letting go a little bit that might be hard for some people to do. But when you do learn to trust that children have amazing questions, and you learn that you don't have to know all the answers you yourself, but you become one of the learners with the children in the class, and of course you know how to bring things forward in a way maybe that children don't. I can give an example of a little four year old girl I was interacting with, and she was collecting a couple of things that were red, and she wanted to take photographs of them, and I asked her well why don't we just make a collection of red? So that lead to a collection of colours, and that lead to a series of documentation panels with these different collections, and the vocabulary that came out of those things, just naming the objects, and the concepts, and serriation, and classification, so many things came out of her idea to photograph something, and I think it was just that I, maybe I'd been reading about it and I felt that I could go with it, and I can see such value in following children's lead.

I think if you think about inquiry in diverse context, what you realize is that you don't need stuff. You need a stance toward the inquiry process. So, it would be educators taking children outside. Children find discoveries in a mud puddle. They find discoveries in anything they observe; each other, or babies. Children want to know why babies cry or why they make the faces that they do. These are all sources of inquiry that don't require expensive toys or tools but rather they require children's natural curiosity and questions. And so being able to build on that no matter where you are is really the skill of a good inquiry educator.

I think if we could be a little more childlike in the way that we approach teaching children, where we allow ourselves to observe what they observe, and it's really just taking that one step further. I mean we as adults have the ability to introduce something new. To ask a question that a child might not ask, but it's amazing what they can ask each other too. I think a great skill is having children build on each other's theories. You think this about why leaves change colour, and he thinks that about why leaves change colour and she thinks this, so what can we do to figure out why leaves change colour? And so then just taking that one step further. Or you notice this in a mud puddle, he notices that in a mud puddle. How can we take this one step further and trusting that the children will have some great ideas? So it is a little bit of faith, but you also have to trust in yourself as a very good educator who understands children.

Pence – community participation (1:47)

My concern is that what we can find are if communities then don't come in at the beginning to even identify even what the issues are, or what the concerns are, then that can lead us down a track that could be far removed from where the community may wish to be and may begin to modify the community itself in terms of its future directions.

I think we in academia and as researchers and development people do need to be very, very sensitive to whose voices have been heard. Who has requested this? Whose voices have we not heard? How can we devise ways, in which those voices can be heard, in our education, in our policy processes, in our research?

I think that what happens when we bring communities and local voices into the process of research and education and the rest, is we're demonstrating a respect for what exists there in the minds of those people and the actions and the thoughts of those people. And I think one of the ways in which that approach is helpful is—sustainability is a key question that you find, you know, being posed. How do we achieve some level of sustainability? I think it's very difficult to sustain something that does not have some sort of rooting into the area that you're hoping it will be sustained.

If there is some of 'us' in there, if we see it as 'of us', 'coming from us', even though it has other sources, you know, that mingle into it, if you've got that ownership then I think you've got sustainability, or you've got a much better chance of sustainability.

I just find this such a rich and fruitful area to work in. And it's not one that you can 'box' and say, 'this is it' and deliver it there. It's going to be different each and every time. And, each and every person is different. Why should, why would we expect anything different of individuals or communities? And I think that this, you know, these are good principles to follow in our work with children. I think this is very much early childhood-based thinking around research, policies, programmes, development.

Pence – cultural context (3:38)

Development is very much a cultural experience; it has biological, it has other things there but ultimately the rearing of children, how we understand children--their place in the world, the family etcetera--those are cultural issues.

We have a situation where over 90% of the children of the world are in the, what I would call the 'majority world' or the developing world, but over 90% of the literature regarding those children is coming from the 'minority world' or your Western perspective. So there's clearly a dislocate there. Unless one believes that that context doesn't matter. And I'm an individual who believes context does matter; it matters greatly.

What happens then, is those ideas begin to dominate and begin to suppress the local perspectives and views. They carry a power. They carry finances. They carry all kinds of strings, if you will, that are very difficult to resist at the local level or the cultural-community level. And we can see this very clearly, this history, in Canadian relations of dominant society and Aboriginal communities. And what we can also see is the effect, the catastrophic effect, of this suppression of culture, and identity, and values, and beliefs and the attempts to replace it with something else that comes outside.

So it's not simply an intellectual concern, if you will, an academic concern, it's a very real concern in terms of how communities play out their lives. How they understand who they are. How they are who they are. We were recently at a presentation talking about the 6,000 languages in the world, and of those only 3,000 are spoken by the children and languages are a manifestation of their culture. The dying off of those is something that is significant, not just for those communities and those cultures, those language groups, I think, but for all of us. I think we're all the less for the dying out of those ideas

I see a part of what I think is important being not only bringing and sharing ideas that are current and recent in the Euro-Western perspective, North American centered. Those ideas are not--I'm not saying let's not do that, that they're evil, they're bad etcetera. They are useful. We do need to be aware of those but they're not enough. They're part of the story. They're not all of the story. And much of the rest of the story lies in these communities and cultures which do not have access to, quite often, to the avenues of getting that information out. You know, the finances, the structures, the infrastructures….. I see all of us as being enriched through that kind of a process and it's not 'either or'. It's really a 'both and' is, I think, how we need to approach this.

I have real concerns about the world outside where the ideas may get formulated and then being visited in. So we need the opportunity to hear and to listen, and then to find creative ways of interacting that aren't privileging, unduly, one idea or perspective over other ideas.

Perlman – meta-cognitive language (2:22)

Meta cognitive language is language that shows awareness of the other. So any kind of conversation that speaks about the other person's position, knowledge, understanding, feelings, reflects the speaker's understanding of their interaction partner. I think that at its sort of simplest form, researchers have generated lists of words that reflect that knowing understanding. I've applied that in child care. So just counted how many times does staff use meta cognitive words like when they talk to the child, do you understand, talk about knowledge, talk about feelings? It's a very simple, straightforward to much more complex kinds of things like trying to resolve a difference whether it's between the child or an adult or between children working towards solutions that take both children's perspective in to account. So turn taking, sharing, things that in kind of the negotiation language to the extent possible are win-win. Seeing that as the ultimate goal so that both partners can have as much of what they want as possible.

We're finding that people could do a lot more of it across contexts – within families certainly and also in child care programs and early childhood education settings that there's not a whole lot of it going on and I think that's a really good target for interventions and training. And by interventions it could be just professional development opportunities for staff in child care programs just to sort of remind them, scaffold for them, that that's something they should be doing with the kids they care for.

Because it's associated with better social outcomes. So the kids who are good at it, who pick up earlier that other people have feelings and needs and rights, have better social interactions. It's true for adults too. But I think it's a reasonable skill to teach, not reasonable, an important skill to teach kids.

Portela – WHO maternal health (7:06)

It's clear that not having care at the right moments leads to higher illness and higher death. Of course, the health of the mother directly affects the health of the baby. There is even statistics to say that, when mothers do die there is a higher level of deaths in babies thereafter also. So, when a mother dies in pregnancy and child birth, then there is a higher tendency or likely that her baby could not survive also.

It is very hard to make an attribution to anyone specific intervention, and that's what's been hardest to even help programs understand. Because other areas have that magic bullet. I do one thing and I can make the direct link and say, this is what made the impact. We are not fortunate enough, maternal mortality and newborn mortality is much more complex than that. So, in fact it is multi-pronged approach, several strategies and in a program that are promoted going from policy to clinical care to improving access and services to even structure things. In order to improve access, you need to look at transport, and then all that health education parts. So generally, a successful program has a combination of those. There are some key factors in there, like having the presence of skilled attendant, and ensuring quality services. But again, it would've been unable to attribute it to anyone element.

One of the things we've tried to help programs look at, it has been, messages are very important. But getting information alone will not help to improve things. It is a very important part of it, we do not want to diminish it. But there is other things programs can do, particularly at the community level. So, one - we've helped to identify what are some of the promising interventions that a program looks at, beyond what's done in the clinic but community-based approaches and not just services in a community. Things like birth and emergency preparedness, like transport schemes, like working with men, like defining a new role with TBAs. How can we support programs and taking a look and being strategic about incorporating them.

And then there is this whole part about community participation, we often tend to leave it to NGO's to do. And I think one of the major guidance that's come out in the last years, through the renewed approach for primarily health care, through the social determinants. Is that community participation is an integral part of programs, but programs don't know how to do it. So, the fact that the government takes on board, make sure communities are heard, women voices are heard, and identifying the key problems, identifying the solutions doesn't mean that the government is the one to implement everything. Then the government worked its partners to say: Ok, who is best at this. But if government doesn't take it on as parts of their philosophy of working, again many of these problems will identify maternal newborn health. It is very difficult for the health services alone to do them. So, we try to give guidance at more that kind of level, programmatic level.

The part of the problem with this area of work that I am talking about, it is not well evaluated. And, there is one of the realities is for clinical medicine, there is a way of providing evidence and providing guidelines, but of course based on criteria, which we can't apply to these more social and policy areas. So, it's difficult, there are many lessons learned about what has worked, what has not worked. We always come to similar conclusions. Maybe one of the

main lessons learned has been particularly at the community level, just having these - you know - hoping than one intervention like just providing information relying over that, that alone doesn't work.

But, it's really difficult to say, even for the lessons - the good lessons - because there is such a gap in research. And so, maybe one of the areas we are trying to provide guidance is we don't expect to have random control child's or the same as clinical child's, but there are ways to improve research in this area and not all programs have the money to do it. But, even funders should be aware that it's an integral part and if we want learn better and be able to say specifically what have been the big - big mistakes rather than the generic ones we know now. Like, you didn't ask communities or communities didn't participate. They all fairly generic, we have some specific for certain interventions, like maternity waiting homes, or other things. But, they are all fairly generic and you not so surprised when you read them, you think why we don't know that before? Big problem is we need to be a little more rigorous in our research.

I think now more and more, again people are aware that with this use of evidence-based medicine; I think everyone become more aware. It doesn't necessarily apply to the programmatic areas. And it's not that we know everything in the clinical, there is still a lot of research to be done for the future but we do know a lot in the programmatic areas for countries now is just important as the clinical areas. So, they've all kind of moved - as you said. Now, helping countries to decide to prioritize based on limited budgets, that's another art in itself. And it's one of the areas again through better costing, through better understanding of cost benefit but that also can have its limitations. But, it's just putting a number of things on the table and being very context specific rather than - you know - thinking that something that worked in X country or even in X district in X country will necessarily work in another district. So, learning to adapt and consider the reality and how to adapt to that reality, I think are ways to move forward.

We've learned more and more to work, you have to work for Ministry of finance. Who decides the budget in the end? And all of that health - you know - information. Ok, it's useful to the Health Minister, but what does the Finance Minister want to see? And how can you support the Health Minister in making those kinds of arguments?

If you can really do a cost benefit analyses you would see in terms of using well a resource and that's in fact what happens. By the time a women reaches services, she is in such a bad situation that there is nothing the services can do or it requires so much treatment that it's extremely costly. When in a fact, if people could be supported to take better care of themselves at home, go to the services at the right moment I feel you could see the benefits in terms of cost and having more modified cost of your health system. It's one of those theories you can’t prove, it's a logical theory. Is there anyone study that shows those results, no. But, in fact that's the whole theory behind health promotion, prevention and services in clinical care.

Portela – WHO maternal health access (5:19)

There is a lot of reasons why women don't access care. We can start from the household decision making process where - you know - she doesn't make the decision, someone else does. And that someone else may not be home at the time and in case of an obstetric emergency for example her husband may be out in the field and she can't leave until he comes and confirms her decision. So that's one example. Another example is just not knowing what the signs are, or when to go or even where to go. So not having appropriate information is often another problem.

Then, there is a whole other level of issues; for example, related to transport; or other financial barriers which tends to be one of the biggest barriers to accessing care. Then, there is another level, that if she does finally get to the services, often there; there is not the quality of care. They don't treat her right away, or she herself may not want to go because the service doesn't speak the same language as her. She feels she is not treated appropriately; there is certain cultural aspects which are important to her and her family, that the services don't address. So, many years ago, there was a model put forth, it's called the three delay model and it kind of covers those three areas. One; what happens in the home. Two; those kind of more structure, not being able to reach because of geographical transport. And three; what happens when she finally reaches the services. That's been expanded thereafter, but, in term of the explaining what happens why she doesn't reach care it's a useful model.

We've seen some ways of resolving transport that, again if she is in emergency, but it's along that line. What is available, that, while they are improving the roads, while they are finding ambulances and a budget for the ambulances that can help ensure women reach services. And again there has been a number of options, some have been a scooter with a cart attached so that she can be transported, others has been by horses and uncomfortable as it is. Others are, for example, they make a deal with the bus Union, so that the drivers allow her to get on - you know - and don't charge her, so that she can make it. Another is by radio contact calling the police which is an example from El Salvador and they come and pick her up using cell phones. So, there is many different options depending on the context. And again it's meant to be until the bigger problems are solved. But having an ambulance, having twenty-four hour service with the ambulance is not always possible, even though it is on the list of "to do's".

With one of the interventions working with, what we call them decision makers. Decision maker in the household is often the husband, or the father, or the mother in law. And so again, how do you, we can give her all the messages we want in antenatal care, if we don't help her, for when she goes home and has to face questions or pose why she should do XYZ recommendations we've not been very helpful to her. So one of the interventions, is particularly working with men to help them transition their role. Because men do have a role, and in many times we feel they would also want it. They report that they would like it to be more positive and they also need support in doing that. And that could help the household dynamic. And, it's not as simple as that, but we do try to encourage programs to work at different levels, at individual level, at a family level, at a community level, at a service level, and then of course at a policy level.

In Guatemala, there was work to discuss with Mayan communities, why women didn't seek care. And it was related to the color of the walls and also the positions allowed at child birth. We have others, so when the services addressed that either there is increase use in services for child birth.

Haiti is an example where there is a very big program to address financial barriers, where women in fact are not charged. The services have to show, fill out a form and show that they provided services. Also, TBAs are invited to accompany the women to the services and they are paid a fee for that, so they are not losing their income. And they have incentive to also provide the women. The woman is also reimbursed for transport and that has been very successful and increasing use of care in population.

There is other examples, where working with traditional leaders or community leaders. And again, in El Salvador we have a case where there is a local committee - and it was purposely made intersectoral - including the police, the mayor's office, the truck drivers' union. And they've been successful in arranging transport for women's and babies not only for emergencies but for routine care. So, again since I have spoken largely about barriers, the kinds of examples that I bring are those that; yes through health education, yes through health messages; but again the importance of bringing a multi-active group together to discuss what are maternal newborn health problems but also what are solutions and then addressing them together.

Rasheed – intervention team (2:14)

We have a ratio of one to ten, we have sixty lady health workers in three intervention sites and we have six girls so far ECD, we call ECD facilitators, and we have a team leader who works in close liaison with me and Dr. Aisha on the field side.

The intervention delivery team was hired three months before we actually trained the lady health workers
So, it is a gradual training and constant training and supervision with field practise and initially what they had a baseline training you have to train them as a trainer, how to deliver a training and then how to be a mentor, how to be coach on the job and on job supervision was very important with the intervention support group of the project and the lady health worker as well.

Because it is an observational skill, to really observe somebody to, whether she is reading the signs of the child or not, whether she knows her child is ill and he is or whether she knows her child is crying because he is angry and the way she is responding and is she responding appropriately or not. So, I think there is something difficult that will be something who is experienced with caregiving. Not just observation and teaching somebody to observe. I teach the intervention team, the intervention team then teaches the health worker, the health worker then teaches the mother, it's really a chain and you need quality, how to really help somebody observe because children can't speak.

So, really you have to make out through the observations and constant observation and interaction of the child to really come to understand what the child needs and wants and what's really, he is angry or is he ill or read signs and respond to that.

But they have really impressed and they have gone very far and they are good really trainers and coaches and good report writing skills and communication skills they have developed some of them and it's really, it's motivating for all of us, for one who trains to see your trainees come up with the skills and come up with their own ideas and innovations for their own community.

Rashid – benefits of teacher training (0:41)

Over a long period of time I find that more economical because here you have somebody whom you have empowered, right? The course is not that high and you have given somebody a skill and even if that teacher does leave the school, she's going to be a mother or somebody, a caregiver and she's going to use that knowledge. So in the long run we're creating a critical mass of experienced people who know the importance of early years and now kids need to be nurtured.

Rashid – care for child development (3:27)

One of the things about care for child development is the whole notion about where it starts. It starts at conception. So the care for child development is an opportunity for us within the AKDN as a network to really begin to focus at the right time and that is with the mothers at conception and really ensuring that the first years of life we really impact.

And then the other interesting thing about the care for child development is this whole idea that, you know, people think it's really technical. But when you come to look at it, you know it's really simple, you know. Talk to your child. Play with your child. Play using simple household materials where, they are there in the homes. But because caregivers are not aware, siblings are not aware, grannies are not aware, it's like the first year of life for a child is just being fed, you know, clean and the baby put to sleep.

It's the whole idea of using very simple materials. Using the time well with the baby to talk and play with the child. And what's also very interesting is in practice, when you are with caregivers and you encourage them to do play and communication, you know and they say, oh, so this little one, you can communicate, you know. Just the fact that you can copy the child's action and the voices and all and the baby really responds and there is this give and take and they become so excited. But what I've found very helpful all this time we've been implementing care for child development is the whole idea that when you explain in very simple terms to the caregivers that why this is important, then they just catch up. Oh, ok, so it creates pathways in the brain; this will help in the brain development and they get it you know and they; and that's what I feel keeps them going, sustains the whole idea.

What we have seen is caregivers who have been doing it, you know, they tell you we have a very good relationship with the baby, you know. And when you find out why, says you know, I know what the baby wants. Ok. I know what the baby wants. How do you know that? But I've been with the baby. I've been doing this with the baby. I know this cry means this. You know when the baby moves his head away from me I know he's not interested in play or he's had enough. So that creates the bonding, through the play, through communication and all these little things they do with the baby, they form the attachment. And they are very responsive. They're sensitive as well as responsive to the baby's cues.

Rashid – Madrasa preschools: development of curriculum (2:38)

Actually the curriculum, let me give credit to the Kenya Institute of Education because the base of the curriculum in use came from that. KIE in Kenya, already had a curriculum for early years. Actually not a curriculum, they call it guidelines. And what happened in the initial stages was the pioneer of the program, Bi Swafiya, worked with the Muslim maalims. These are the teachers who teach in the Koranic schools, who teach religion-work with them, sit with them around the table so they could help her come up with the content, the religious content, that could be interwoven into the secular part. So that was the beginning. All right?

And what we did again later was to look at what other curriculums that are out there that we can adapt to fit into our cultural context. And we adapted the *High Scope*. So what we do is we use the *High Scope* on the plan-do-review and all the other circles and so on, within what we have. And so you will find that when you go into a Madrasa Preschool, you'll find the learning areas, you will find lots of materials, and the emphasis is to use locally available material, not go for the shop things. Because it cannot be sustained in the communities. We are looking at marginalized communities.

So teachers in their training are taught how to develop and use these materials. At the same time, all the other important component of the curriculum, in terms of how do you get to nurture a child so that you have all the six domains well-developed --it's all there. And I think the others aspect is also with the parents: how do you get parents to support this positive nurturing. So there is a whole part where we're working with parents to ensure that they carry forward what is happening at the school level.

So the curriculum is like any other curriculum, but it's rich in the sense that it has adapted the High Scope plan-do-review. It has also other aspects of health and nutrition, and also, it's geared towards the child within this context that we are talking about in East Africa.

Rashid - Madrasa early childhood programme (3:14)

The initial thought of the Madrasa came from the community itself. So I would say it was a needs-driven idea from the community itself in a sense that they felt the need. Their kids were not doing well and they wanted to know why they are not doing well and they wanted to ensure they completed school. What they discovered was that the children, the Muslim children at the coast were not going to schools because the schools were run by missionaries so they were more Christian-oriented and the parents feared that their three year olds would kind of not have a very good Islamic background if they started in such environment.

And so this whole idea of how do we get Muslim parents – how do we win their confidence to have them bring their kids into the preschools, came about. And this is where the Madrasa idea was born. That, let's use the existing facilities in the communities. In any community that you go that is Muslim-oriented you will always find a Mosque and a Madrasa. And the Mosque is there full time but the Madrasas most of the time are underutilized during the day. Because kids go to school and their functional in the afternoon and evening so why don't we use these buildings, refurbish them and then have them as preschools.

Then the other need was who is going to be managing the children when they are there? Right, so they had to come up with a curriculum that fitted the wishes of the Muslim parents and that was now the Islamic aspect being woven into the secular preschool curriculum. What came out of that was the current curriculum that is in use. At the same time, the teachers were girls in the same community who were actually identified by the communities' members themselves who agreed, the girls agreed to be trained as preschool teachers. And then, also the community had to come up with a committee which was a volunteer body that would manage these preschools.

So you see that it was, most of it was actually driven by the community. They took ownership from the word go. So what the Madrasa does then is actually to train the preschool teachers, train the school management committee and now we've evolved from an early childhood education program to an early childhood development program over the years. And we are now currently working with parents and other community members in different areas to ensure that the child is developed in a holistic manner.

Rutter – biology (2:19)

The idea that all the answers lie within the cell is an absurd oversimplification. So that what's going on in the cell provides what is relevant in relation to learning, emotion, social relationships, so we need to understand how that happens, but the precise ways in which this is operated out in social relationships or emotions will be personal.

Now, some scientists, not me, get agitated that are you saying then that it's all free will? No. On the other hand what I am saying is it's not all deterministic. So that the goals of physics are very much to find a law that applies to all matter in all situations all over the world and indeed in other planets if that's what you're interested in. Biology isn't like that. Biology is probabilistic; so that we know that at a very simple level that the construction of the brain involves genetic programming of the neurons where they're at, the ways in which the neurons migrate from one part of the brain to another, but it doesn't get it completely right. It's probabilistic and therefore what it built in is a way of pruning, so the neurons that are working and serving a useful purpose are retained, the ones that aren't get deleted. That's typical of biology as a whole and why minor errors in development are almost universal.

Rutter – environment (2:52)

What it means is that aspects of development, including brain development, are influenced by experiences, so that the notion that all of this is independent of what's going on in the environment is just not right. But there are three rather different ways in which experience and brain development come together. Firstly, there are certain sorts of experiences that you have to have for normal brain development to take place. So that kind of work that Hubel and Wiesel did, for which they won the Nobel Prize, showing that you needed to have patterned visual input for the development of that part of the brain dealing with vision would be an example of that kind. But then there are other experiences which are different in the sense of functioning to adapt the brain to the environment at the time, so that the brain, like the body as a whole, is an adaptive organism and so that the brain will develop in particular ways according to the environment.

The most clear-cut example of that is the fact that up to the age of about six months all babies throughout the world make the same discriminations between sounds. But from about six months onward, all of that changes and the Japanese babies are able to make discriminations on sounds that are in the Japanese language, English babies do it in English. So that here it's not saying that it's needed for normal development, it's simply saying the brain develops according to deal with a particular environment's experiences. But then there is the more general feature that all experiences bring about brain changes. So that the example that at least English people like to remember is the one about London taxi drivers, who have this horrendous three-year training program to learn about the streets of London, and that has effects on the size of the particular part of the hippocampus, which is a small part of the brain. So experiences in adult life also change the brain. What's different about that though, is that it's not, as it were, influencing the development of the brain in a way that carries on. These are things that come and go.

Rutter – responding (2:28)

Well I think the most important thing is forming relationships with the children. Now obviously as a caregiver or professional of some kind is different from being a parent or a grandparent, but relationships are such a crucial part of growing up that that's important. One aspect of that is the recognition that children are different. And that what suits one child won't necessarily suit another and an important part of being a good caregiver is a recognition of responding to each individual child. Responding in the sense of needs but also responding to what makes them interesting. Of being able to have fun with the children and that even when one's involved with teaching or discipline or whatever, nevertheless, good humour, fun, is an important part of that.

And recognition that the idea of experiences impinging on a passive child is really just not the way it works. Even babies process their experiences. They think about what's happening to them, they draw their own conclusions and so that one needs to get away from the notion of stimulating children to a notion of children being active partners in this, and your job, as it were, is to bring that out, to make it fun, to engage their curiosity. And to recognize that children who ask awkward questions are actually learning. And that one needs to be able to respond to that. What one does not want is simply a compliant child. You want a well-behaved child of course but you also want one who's provocative.

Salaon – antenatal care (2:51)

Expectant mothers I encourage to attend the antenatal clinic four times during their pregnancy, mainly for their health benefit and the benefit of the unborn child. It is important to ensure that the unborn child is healthy and this from the ECD perspective would target their nutrition. How are they feeding? Are they feeding well, adequate enough to cater for the unborn baby? Are they feeding well enough to cater for their own health because if they do not cater for their own health, it means the unborn child will be affected. We encourage them to begin to speak to the baby while still in the womb because it is important. Sing to the baby, talk to the baby, massage the baby, encourage the spouses to massage the baby, to feel the movement of the baby because we know this contributes to their language development when they are born. It also encourages or improves bonding from the mother perspective, from the male caregiver, and we encourage this so it begins early in life not when the child is born. So it's critical that the mother understands she has to be healthy for the sake of the unborn child. The people around her also have to support to ensure that she's not overburdened with other activities that will really affect her health and the unborn child.

In this part of the world, where we are working this sounds very strange. In fact, most of the caregivers, the women will say we don't allow the men to come close to us. They should not be touching our bellies. But when we talk about it, they're like, "What? Ok, I thought this was my business. So then I will be allowing him to feel our baby. It's no longer my baby but our baby." It was very interesting actually for them to learn that the man can come and actually touch your belly. The man can speak to the baby, to the unborn baby. Yeah, it was such a surprise to them but they have embraced it, they are happy. In fact, as some say, oh, we are already beginning to do that. Yeah, not easy because of the cultural aspect but they are beginning to realize the benefit of doing that.

Salaon – grandmothers (2:19)

As for the grandmothers who are taking care of orphaned children, all they know is that I need to get you money to take you to school, if you are older. I need money to buy you food, I need money to buy you clothes. Play? What do you mean? When do I get to play with these children? I'm overburdened. But when you tell them that play will actually improve even the way they feel about it, they are very happy about it. They can call the children, they can sit with the children, tell them stories, sing with the children, you know. They are beginning to see the value of building play. It's not just about the physical needs. It goes beyond that. And happy children, especially when they are affected or infected by HIV, improves even the uptake of their nutrition. You may give them all the best food but they are not just happy. So when you begin to play with them, to appreciate them, to make them feel wanted, it also makes that grandmother who is overburdened also feel better. Ultimately, we see a community in future that is well supported to work with the children that were fed well, they received the good nutrition, they were stimulated. So when they go to school, they simply just move. So the benefit is for everyone. It benefits the caregivers. And mostly we've seen for depressed caregivers, if you build in counselling, encourage them to play with their children, it helps them get out of that depressive kind of state and begin to appreciate themselves and what they can do with the children. So the benefit is all-around. It's for everyone and it will benefit the country in the future.

Salaon – maternal depression (3:07)

I think from our work here in the community, we've identified cases of violence during pregnancy that actually affects seriously the expectant mother and she goes in to this depressive mood and she's not able to feed well for herself and for the unborn baby. And most often depressed mothers will not even attend antenatal clinic. But if they are identified, for example, during a household visit, the community health worker will ensure that they come and visit the health facility. The health worker has been trained on how to help this caregiver, bring out her issues and really have that one on one interaction that will help her see the benefit of getting out of that. Addressing; because we have to address what is ailing. If it is violence then it has to be reported because we have structures that address domestic violence. Now our interventions target depressed mothers. When depressed mothers play with their children, like I mentioned, it helps the mother to feel good about it. If depressed mothers do not understand that they have to take care, they have to be responsive to the needs of the children, that it affects the children. They will not feed the children. They will not take care of the children in any way. They will not play with the children because they're engrossed in to this kind of depression. But the minute you help them out of this depression, then they can begin to be responsive to the needs of the child. So the health providers have to probe when they come in. They really have to observe even as they come in because some will hide, most of the women will hide. You do not know they are actually going through certain challenges. Either they're being beaten up or they're being mistreated. So it's up to the health worker. As soon as the caregiver walks in, to observe and to kind of begin to dig out what could be ailing. Even by observing how they hold the baby. They could just be pulling the baby this way, that way. That's enough to tell you this mother is depressed. So you have a responsibility to ensure that you address what is ailing and also link them up to structures that could help this and then counsel her on things that she could begin to do that would make her feel better.

Santos – experience (1:55)

We've learned more in the last 30 years about what's happening in those early years of development than we ever knew in the preceding 2500 years. So most of that research is new and has only been recently begun to be applied to thinking. In terms of what's happening in there – it really starts from conception. Like often we think about children sort of after they have been born and we often need to remind ourselves that so much happens in the prenatal period during pregnancy, and so, in terms of how we support kids it really needs to start with supporting parents and pregnant moms especially. In terms of what's happening developmentally, the story of how the brain develops I think is what really captured the imagination of the public and everybody that's been working on this today.

The thing you refer to in terms of sculpting is sort of a metaphor for what happens at the level of the neurons in the brain. So unlike most of the rest of living beings in the world, human beings, at birth, their brains are not formed fully developed, that is, that after the child is born much is still required to help that baby[1]s brain develop in a way that will increase that child[1]s life chances and potential.

And that, as I say, experience-based learning is heavily dependent on the social environment of the child. So in addition to the things that I think we take as givens - a child needs enough food and water, and warmth and physical safety. The way the brain develops in the early years is heavily dependent on the presence of nurturing relationships, on the presence of caring adults in the child[1]s life, such that, they talk about the sculpting of the connections in the child[1]s brain, really depends on that interaction. So it's really incumbent on us, from that research perspective, to consider how best to support that happening.

Santos – importance of caregiving (2:21)

Although a baby is born with all the neurons in the brain that an adult has, about a hundred billion, sort of like the number of stars in the milky way is a way of thinking how complex the brain is most of those neurons are not well connected, hence they are dependent on the experience of the child in the first few years and pregnancy period. When you look at pictures of the brain at that level you see those connections happening through those early years. You find that, at around that age two and three probably you looked at from a developmental perspective, that¹s the time that there is the most connections in the brain because the child¹s brain is so active. In fact, if you define being smart as the ability to learn new things, babies far and away out pace adults in terms of their ability to learn. They are literally geniuses in terms of the way they approach the world.

Another thing we¹ve learned about those early years is that it used to be assumed that babies were born as blank slates, they don¹t know very much, they didn¹t do very much, they just sat there, cried every now and then, and then you feed them. The truth is with the new research is that babies are born with already an enormous amount of knowledge of how the world works and how it is organized and how to live in the world. What they rely on caring adults for is to help shape that learning further in all domains of development, their social development, emotionally and in terms of their learning ability, so that sculpting that occurs really depends on that interaction in every way with caring adults, whether that¹s playing, talking or reading or any number of ways that adults typically interact when they encounter a child.

We find is that there has been a lot of worry on the part of parents and adults that care for children as to what you do with these babies and how best to maximize their development. When, in fact, the kinds of things that I think the research shows that most adults unconsciously do when they're around children, which is to pick them up and cuddle them and play with them and talk to them in baby talk and all that. All of those things that we sort of unconsciously do are in fact some of the best things we can do with a child. You don't need any special toys or books, with apologies to the people who sell those things. What you need is a caring adult with a consistent time, space and opportunity to be in the life of the child in that important period.

Schonert-Reichl – mindfulness research (2:27)

So mindfulness is one area of research that has been gaining increasing attention. Mindfulness defined typically refers to being in the present moment without judgment and paying attention on purpose. For the past decade I've been studying mindfulness in school age children particularly around a program called MindUP developed by the Hawn Foundation. The MindUP program is for school age children that integrates mindfulness and social and emotional learning. So the children that receive the program which could be pre-K to grade 2, 3 to grade 5, 6 to grade 8, actually three times a day practice mindfulness. They call them "brain breaks" actually, where the children take a moment, take breaths, pay attention to their breath. But they also do things like mindful movement, mindful tasting – a favourite among many children, as well as mindful listening. And for the past decade I've been doing research on this MindUP program to see does it really benefit children in terms of their social and emotional well-being, in terms of their ability to self-regulate, decrease stress. A lot of those factors that we've seen in the adult research on mindfulness that shows these positive benefits but we haven't known until now. And my research on MindUP with grade 4 to 7 children and another study on grade 4 to 5 finds in fact, that this mindfulness program or social and emotional program with mindfulness components actually does promote positive well-being in children, decreased stress as well as make them more positive in their lives with friends and with their teachers. One of the things I just want to say, it's interesting in this study that we looked at peer relationships and we asked kids to actually nominate their peers on how much they're kind, how much they help others, how much they cooperate. And the children who received the MindUP program increased on all of those compared to children who did not receive the program, which we call a control group. Those children actually got worse throughout the school year. In our research on the MindUP program, we not only found improved social and emotional skills as well as increased capacity for empathy and caring for others, we actually found that those children who received the MindUP program had math test scores that were 15% higher than the children who did not get the program.

Schonert-Reichl – MindUP – engaging students (1:37)

When I began doing this work on MindUP, this mindfulness-based program, it was going to be implemented in kindergarten classrooms up till grade 8. Well, I went in to it very skeptical. I thought, ok, really? I could not imagine kindergarten children even grade 1, sitting still for a few minutes breathing, paying attention to their breath. I thought this is just not going to work and boy, was I proven wrong. I felt that they really got it quicker than the older children. It was like they were more ready for it. I went and visited a lot of kindergarten classrooms and the children right away had that ability to be in the present moment. And if you think about young children, they are in the present moment. You know the idea of taking a mindful walk and looking for things that you could see on the sidewalk – they're so present. They pay attention to those things. So it really was an easy sell for the little ones. A bit harder sell for the older kids in some ways because they are a bit more skeptical. But the one thing about the MindUP program that I think is a real draw for all children is it begins by teaching children about their brain. So they learn about the different parts of their brain, the prefrontal cortex, the hippocampus, the amygdala and they learn about the functions of those parts of their brain. And what I think really gets children engaged to learn that they can have control over their brain, that their thoughts – And teachers really love it because they feel like it's not just taking away from the curriculum, that they're actually adding to it by bringing all the latest research on neuroscience.

Shanker – brain development trajectory (4:46)

At the beginning of the therapy, what we see is, we get the standard measures using various psychometric tools that tell us exactly where that child is compared to their peers in terms of their ability to process information, solve problems, use symbols. And then we begin about 35 hours a week of therapy in which we work very closely with the parents. And then at regular intervals we study their brain. And what we want to see is, is there a progression in the activation of the anterior cingulate. In other words, are we actually, beginning to bring that part of the brain that wasn't active, that wasn't processing this social information, can we bring it online?

So, the children in our study range in age from two until four. And they are all at roughly the same kind of a developmental level; it's a level at which these kids are having a lot of trouble managing social interactions, processing social information and they have problems with language and problems solving. They also have numerous biological problems that we work on for example, using occupational therapists.

One of the questions we are most interested in is, is it possible to enable a child who for biological reasons has had this kind of a skewed neurobiological trajectory. And what we mean by that is, that the course of how their brain develops has been disrupted because of their inability to process social interaction, to engage in typical social relationships which according to all the work we've done, are the sort of driving mechanism in the development of the brain in the first couple of years of life.

We know, that if we take an older child, a child of say five or six, who has not had the social relationships and give them very intensive therapy that what we can do is, we can train them to, let's say, memorize certain kinds of social scripts. In extreme cases the child might memorize something like "when someone raises the corners of their mouth and their eyes crinkle at the edges that means they're smiling and happy. Happy means that they like what you are saying. And this is all a very kind of rote memorized task for them and we try to give them lots of tasks.

When we study the brains of this sort of a child what we see is that those parts of the brain that regulate memory are very, very active. So what we've done is we've capitalized on those centres, those systems, that regulate memory but we haven't really touched those systems that regulate social information, social interaction. What we want to know is, if we start to work with a child much younger than this, when the brain is still fairly plastic, when the brain is still capable of forming substantial new connections, and if we adopt a therapy which is designed to mobilize the child's awareness of, and understanding of social information, can we get those parts of the brain active, developing? So that instead of it being the memory systems that regulate their social interactions, it's, as in with most of us, the parts of the brain such as the anterior cingulate and the orbital frontal which unconsciously regulate our social interactions.

And so far what we're seeing is, that if we can get the child at a young age, while we still have a window of plasticity, that there are very encouraging signs that it is indeed possible to return a child to this sort of healthy neurobiological trajectory.

Shanker – caregivers (1:53)

However, nature had one more ace up its sleeve. Nature, since it was giving birth to these brains that were so small and undeveloped at birth, could also use the opportunity to make our brain highly adaptable. We are the most adaptable species. The infant's brain can adapt to anything from the Arctic to the Sahara, to a very safe and secure environment to a very hazardous environment. The connections that are formed in the first two years of life are molded by the kinds of experiences that that child encounters. And the primary vehicle for these experiences are the caregivers. This is a defenseless creature that relies on its caregiver for security, food and learning, and stimulation. And so what we find is, that beginning at birth, through the caregiver's facial expressions, through the gleam in their eyes, they are stimulating and regulating how that little baby's brain develops. What sorts of connections develop?

We know that there's an enormous explosion of the growth of the synapses, of synaptic genesis in the first eight months. At that point we know that a significant process of pruning starts to occur. Those connections that are turning out to be most useful are the ones that will be kept, that will be preserved, that will serve as the sort of foundation for the growing architecture of the brain. Again, these connections come through the primary caregivers. They serve as the sort of conduit--the lens--that introduces the child to the world. Their gestures, their facial expressions indicate to the child: this is interesting, this is new, this is frightening, this is to be avoided.

Shanker – defining self-regulation and self-control (1:53)

One of the questions that we get asked most frequently is, “What exactly is self-regulation?” So we actually did a study on this and it turns out that there are 447 different definitions of self-regulation and it’s no wonder that people are confused. In simplest terms, what that refers to is how we manage stress, how we regulate the amount of energy and tension that we have and then recover from stress.

There are all these hundreds of different definitions of self-regulation and what’s very interesting about them is how many of them are actually about self-control, not about self-regulation. It’s very easy for parents especially to be confused. What’s the difference between them? There’s a very simple guideline for how you’d distinguish between them, at least conceptually, and that is self-control is about inhibiting an impulse.

But self-regulation is really about addressing and removing or preventing those impulses in the first place. The impulses themselves are invariably a result of heightened stress and so what we’re working on when we address self-regulation in a child is the various kinds of stresses that lead that child to become highly impulsive or to need to exercise self-control. So what we’ve learned from doing this over the years is that self-regulation is what makes self-control possible or in most cases unnecessary.

Shanker – developmental disorders (1:47)

We created this self-reg wheel, and this wheel is telling us something incredibly important about self-regulation. If you look at the wheel, at twelve o'clock we have developmental disorders, and by developmental disorders we mean things like: autism, or ADHD or learning disorder, and the point of implicating self-regulation here is not to say that these disorders are caused by problems in self-regulation, these are neuro-genetic disorders, these are disorders that, you know, everyday we're learning something new about the sorts of core, perceptual and motor mechanisms that have been impaired in these children.

The nature of the biological, the neuro-genetic challenges that these kids with disorders have is such that it interferes with, it obstructs these interactive experiences. It obstructs their capacity to engage with their primary caregivers, so as to deliver this information to the parts of the brain that are coming online. So what happens is that the child develops problems in self-regulation as a downstream consequence of the neuro-genetic challenges which interfere with their social interactions. Now what happens is so many of the symptoms that we associate with the various developmental disorders, so many of these symptoms are actually downstream consequences of the impediment to social interaction which in turn causes impediment to the development of self-regulation.

Shanker – developmental expressions of stress (2:37)

So the question that you've just asked me is whether there are what we might call "developmentally identifiable landmarks," whatever, to differentiate between say how a toddler might express stress behaviour versus a teenager. It's a difficult question and I'll tell you why. The first part of the question is yes. So typically what happens --let's take a toddler--is we'll see very pronounced changes in facial complexion and they might go very pale or very, very red and will have very pronounced changes in vocal behaviour, so their voice will generally speaking go up. They become very volatile, very labile is the technical term. They become very volatile and their emotions swing all over the place. So those are typical toddler into preschool expressions of this.

One of the things that children are getting much better at is concealing these sort of raw emotions. So they're learning how to suppress their emotional expressions and so on and by the time they are young teens, they can even look you in the eye. They've gotten so good at inhibiting their anxiety, concealing their anxiety that they can look at you in the eye and even maintain a straight face. However, if it becomes strong enough, if the arousal is strong enough that older child or that teen will in fact regress to the level of a toddler. The behaviours will in fact regress as well. This is very difficult for parents, for example, who have an older child or a tween that is truly behaving like a young toddler but because of their age we insist on treating them as a young adult or whatever. But in fact, in functional terms, in terms of what's happening in their brain, they are at a toddler's level. I would go so far as to say that older adults could regress to the level of a toddler.

Shanker – educational outcomes (1:33)

There's a high correlation between mental and physical problems - that a child that has the one is likely to have the other at different points in their lifespan, and so as you go around the wheel you'll see that you've now gone from psychology into classical health- so we're looking at the health crises that we're dealing with as a society until we get to 11 o'clock, and 11 o'clock is educational outcomes. While now we've got just so much research that's come out since 2000 shown that self-regulation is absolutely fundamental, critical to how well kids are going to do in school

Why are we seeing this incredible concordance, this incredible correlation between poor educational outcomes and problems from 1-5 or 6-11? Is it because they're stupid? Is it because they have a low IQ? Is it because they're just not smart enough to understand what kinds of things they should do to enjoy health? No. it's because a common pathway has been impaired. This core pathway in the brain, if it is over-worked in the early years of life, if the child is responding to too many stressors, so that he's constantly putting his foot on the break, constantly activating the parasympathetic nervous system, there will be a cost, and the cost is going to be the child's well-being, and the cost is going to manifest in any of the problems you see on that graph, and probably in several.

Shanker – evolution (2:55)

So one of the questions that we wanted to understand from very early on, is why is the parent, why are the primary caregivers, so important to this whole process of early brain development? And to answer that we began to actually study evolution. We studied this very closely. And there is a growing awareness in the neuro-scientific community that looks at the evolution of the human brain. That nature was confronted with a very interesting dilemma when it was evolving the human brain. On the one hand, it discovered that bipedalism, the ability to walk on two legs, gave humans a wonderful advantage over all other species. On the other hand, it was discovering that a big brain gave us another wonderful advantage in terms of our ability to plan, to remember, to project. This created a dilemma, and the dilemma was how big a brain could nature evolve, while still enabling our females to walk on two legs. Because they had to give birth to this big brain thing.

Nature came up with a very interesting solution. It had us give birth to our babies, in essence, prematurely. Our babies, to quote what Stephen J. Gould said, are "fetuses outside of the womb" for the first nine months of life. So they are born with approximately ¼ the size of their adult brain. Now, nature had to ensure that these babies would receive the appropriate kinds of experience that are necessary for the developing architecture of this emerging brain. So, what nature did was, it gave us all sorts of mechanisms that ensured that the primary caregiver, usually the birth mother, would stay in close proximity with her infant.

And so we have things like certain hormones that are actually released by the baby crawling up the mother's ventrum immediately after birth to search for milk which it does by its olfactory sense. And when we study this we see that it releases oxytocin in the mother, the so-called cuddle hormone. It also stimulates GI hormones. It also does things to the baby's brain. So we have these mechanisms, that are largely innate, that ensure that we will have this kind of close caregiver-infant relationship for the first couple of years, which is the period during which the child's brain goes through this enormous burst of development.

Shanker – example of self-regulation 1 (2:54)

Self-regulation is the story about how much gas a child has in their tank, and what are the things that a child is using up their gas on? The way we started to think about this I put my car in cruise control, and I noticed that I was burning about 8 liters per 100 kilometers, when I was on a flat surface, and then the car had to go up a hill and I suddenly jumped from 8 liters per 100 to 40 liters per 100, and then as I went down the decline it went down to 3. And I realized that, you know, we have this assumption that every child is sort of, you know, they're on a level footing, they're all, you know, if they're not paying attention, if they're not paying attention it's because they're not trying.

Well, I'll give you the perfect example, and then I'll explain its significance for all children. I was in a classroom, I'd been asked to come in, and I'd been asked by the school because the school had a little girl in this class, she was a 9 year old, and she, the school, this child, the child was hyperactive, and the school wanted her placed on a stimulant and the parents were resisting. And the parents were resisting because they had read up about possible side effects etc., sleep problems, aggression, and so really what the school wanted was for me to convince mom and dad that the child should be placed on a stimulant. So, when I came into the class the little girl was sitting in the front row to my right, and I ignored her for about the first 5 minutes, thinking that I could demonstrate how easy it was to control this child's behavior by inhibiting it, and of course it didn't work.

And so finally I turned to her and I said "Yes, sweetheart something seems to be bothering you, what's the problem?" and she said to me: "Sir, sir, sir, I can't hear you because of the noise from the fan". So I looked around and there was no fan on the ceiling, but what there was was an air intake vent, you know, fresh air intake vent, and it was making a slight noise. But this little girl had such hypersensitive auditory processing, that she had to work very hard to block out the distraction from the ceiling fan, from the vent. And she was using up so much energy trying to concentrate on me, trying to inhibit a distraction, that she couldn't control her behavior. And what it told us was she was just like my car going up the incline, this little girl was burning 40 liters per 100.

Shanker – example of self-regulation 2 (1:48)

I can have two children sitting beside each other, and I've got one kid who's ticking along at 8 kilometers, you know, 8 liters per 100, and guess what? Teachers love that kid. That's the kid that, that's the kid that we're going to smile at, you know it's all unconscious, we're going to smile at him, we're going to encourage him, we're going to say: "Good boy, you did it again!" and then I've got the little girl who's burning 40, and we find it annoying, we find it annoying when this little kid is bouncing around.

Unfortunately our behavior is now going to make everything worse because of the stuff I was explaining before. The more we arouse negative emotions in that child, the greater the strain becomes on the child, everything is getting worse now, when really all it was was a case where this little girl was working way harder than the little boy beside her. When you think about stressors, we tend to think of you know, like, what kinds of stress could a child have, but we now know, we have tons of research now showing us that the stress on a child; it might be environmental, it might be familial, it might be biological, it might be the stress of finding bright lights or loud noises, or noises, or just the presence of other children requires an enormous amount of energy in order to inhibit these distractions. The key for these children is under no circumstances do we want to be punitive with that child, do we want to try to control, discipline that child, shame that child, instead what we want to figure out is what are the loads on this kid and what can we do to mitigate them.

Shanker – introduction self-regulation (1:20)

The key to understanding self-regulation is that it is a capacity that develops post-natally, it's a capacity that develops essentially in the first five or six years of life, and it's for that reason, this is the critical reason why we are so concerned about the early years and about early child development.

So how does a child develop this capacity to self-regulate? The short answer is that a child develops the capacity to self-regulate by being regulated. A child is engaged in almost non-stop interactions with their primary caregivers in the early years of life, and the caregiver serves as a sort of external brain who is regulating the child, whose brain is still quite immature, quite undeveloped, and exploding in the early years, and the caregiver has to perform this regulatory function for the child because those systems of the brain are only slowly developing in the early years, and it's through these constant back and forth interactions with their primary caregivers that the child begins to develop the capacity to do if for herself.

Shanker – mental health (3:03)

Now we have this huge and constantly growing body of research tying for example at one o'clock, internalizing disorders: so problems, you know, anxiety disorder, depression, mood disorder, tying this into significant challenges in self-regulation. It's the same with, the next wheel, externalizing disorders, these are, you know, conduct disorders, aggression, bullying, and now we're seeing this as somehow fundamentally tied to problems in self-regulation. This is absolutely critical, imperative for the revolution that's occurring in how we understand, reframe children's behavior, because if it's a problem in self-regulation that lies at the heart, for example, of a child with a conduct disorder, it means that what's happening-that child is a challenge in the first level that we talked about when we looked at the levels of self-regulation namely their arousal regulation, their autonomic nervous system, it's not a problem that their inhibitory muscle is too weak that this needs to be disciplined, this needs to be strengthened through punishment and reward, no, no, it's because the child's nervous system is under, it's been drained too much- too many stressors. And what's happening is the child does not have enough capacity, enough resources to deal with further stressors and that's what triggers the impulse, that it represents what I believe is a truly profound revolution in how we try to, if not prevent, at least dramatically mitigate these kinds of problems that we see at two and three o'clock, these problems of mood disorder, these problems of behavior. We're not going for management, instead we're going to try to understand the challenges on the child and then reduce them.

So the next two wheels you're still in the realm of classic abnormal psych so we're looking now at risky behaviors, so the child's vulnerability as they grow older as they're an adolescent to things like gambling, drugs, and here again we have a growing body of literature saying that what we should be looking at with these children is their self-regulation, what we should be trying to do is trying to figure out is the child chronically in an alastatic load condition, is the child chronically hypo or hyper-aroused, and if the child is than rather than trying to target the specific risky behavior that concerns us like, you know, alcohol or whatever, we want to figure out why is the child in this load condition, how can we reduce it, and thereby naturally see the inclination for the risky behavior naturally dissipate.

Shanker – obesity (3:52)

The next hub is obesity, so we know that this is a very serious problem now, 17% of our children are obese, 34% are significantly overweight, five-fold increase over 25 years. So we've tried lots of these campaigns with very little success, very little effectiveness now, where we're going to educate these children on healthy eating or the need to exercise. The problem of obesity really doesn't have anything to do with will-power, in fact, introducing the concept of will-power makes everything worse, and the reason is that when we look at the stressors on a child, when we look at the sorts of things that are draining the child's nervous system, one of the biggest is negative emotion, negative emotion has a huge draining affect, and that's things like anxiety, frustration, shame.

So now, if you start telling the child, or unconsciously conveying the message to the child 'you're obese because you're weak, you're obese because you lack will-power to resist that extra donut', whatever it is, now this child, on top of everything else that this poor kid is struggling with in life, we've now saddled this kid with strong negative emotion, which is going to further drain the system, so we're doing the worst things we could.

When we look at these kids we're starting to see a fairly significant pattern, the research is still at a very early stage, but what we're seeing is a recurring theme of poor sensory integration. And we're seeing a lot of kids that have poor sensory integration, and it may have something to do with modern life, it may have something to do with, as we look at the drivers of strong self-integration, the biggest driver is play, the biggest driver is physical play, it's under conditions of physical play where the child is driven by strong positive affect, the fun of playing, and play is the most energizing of anything we can do, it's the opposite of a negative emotion, it fuels the system, under this strong affect-driven system, you know fun, curiosity, whatever it is, the child is constantly stretching his body, the child is constantly doing things that create this integration, that create; the brain responds to the challenges we place on it, but if I have a child now that's spending an inordinate amount of time watching a video that's supposedly going to make him bright, and not playing, not running around, not exploring, not discovering, on top of everything else what we're doing is, we are, we are short circuiting, we're blocking those necessary physical experiences which drive sensory integration in the early years of life.

Now this poor kid is locked in a vicious circle because of the poor sensory integration, that child is going to avoid physical experiences as he starts to enter preschool or kindergarten. This is the kid now who is going to be drawn to things like the video game, and so now everything is starting to exacerbate, he's avoiding those very experiences namely running around, playing, etc., which we know, of all the things we've studied, have the greatest effect on balancing the self-regulatory system.

Shanker – parenting and temperament (2:14)

Basically what we want to look at is what does the dance look like if I have a permissive mom, an authoritarian mom, or an authoritative mom and we want to pair that with different kinds of children? So we look at, we have different temperament variables, so we look at the highly reactive child, the highly seeking child, and so the idea here is that a) we will see certain kinds of patterns emerging between these, you know, particular profiles, so let's say permissive mom parent with reactive baby, but then of course all of our research here is driven by the fundamental question: how do we help?

Well in fact now we've got some very interesting science starting to be done on parenting and it's telling us a couple of things: first of all that there's a huge cost in parenting, that parenting is stressful, and we even have research that's now showing us the health costs associated with a highly demanding child. We also have some research showing us that not only is there a post-natal brain explosion in the child there is one in the maternal brain. Her brain is growing also, quite dramatically, in order to cope with the extra demands involved in raising a child. If I have a highly reactive child or I have a child with colic or, it's no wonder that parent stress is going to go way up, and we might see certain patterns of parenting emerge as a defensive mechanism. Rather than pathologizing the parent what we want to understand is how can we reduce, by studying these things, how do we reduce the strains on the dyads, can we help the dyad become self-regulated and then the answer is that the better the dyad becomes self-regulated, the better the parents are self-regulated, the better the child is self-regulated.

Shanker – self-regulation and self-control (3:53)

One of the questions that we've been asked over and over again is how does self-regulation relate to self-control, in fact a lot of people confuse the two, and we know from some research that started to be done in the 1970's and has been followed ever since, that children around the age of 4 start to differentiate in their self-control. What does that mean?

Well, an American psychologist called Walter Mischel designed this classic experiment where you say to a child: "Well you can have one marshmallow now, or if you wait until I return in 15 minutes I'll give you a couple marshmallows". And then you watch the children Now, think about this task first of all. This is a classic psychology task where really it's designed to create an anxiety, so what you're doing is you're leaving a child alone with a temptation in front of them, and you know, the promise of a future reward if he can control his impulse to grab the marshmallow.

So, what do we learn from this task? Well it turns out that about 30% of all 4 year olds can wait, and around 70% can't. So that's interesting, it's telling us that children are starting to differentiate in their self-control already by the age of 4. Then Moffat went a step further- what are the long-term implications? Well, we know that the children who wait, the 30%, score on average 201 points higher on their college entrance exams. We know that they have much lower incidence rates of physical and mental health problems, much less vulnerable to, much less vulnerable to risky behaviors, drugs, alcohol, much more likely to engage in pro-social behaviors, have a family life, earn more money, they'll have a better life. So, for developmental scientists that's both fascinating and disturbing.

We want to know okay, why? Why do these 30% have good self-control? We do these other 70%, why do these other 70% suffer? So we did some interesting things. We took the 30% who do well and we tire them. We tire them with just having them do arithmetic questions, which is very tiring for a little kid and then have them re-do the test. And guess what? They can't wait. And then we took the other 70% and we rest them up. We rest them up with active stretching and yoga, and deep breathing, and soft music, and have them re-do the test, and guess what? A majority can now wait.

Okay, so what's going on? What's happening is the more drained we are, the more anxious we are, then more vulnerable we are to impulses, the harder it is to control, the harder it is to delay gratification. So the point is let's figure out what the drains are. I think what the Mischel task is telling us is that the reason why children are differentiating at the age of 4 is because they're dividing into those two groups I mentioned before- the 30% are the kids that are burning 8 liters per 100, the 70% are varying degrees the kids that are burning 40 liters per 100. And so what we have to do is if we want them to develop self-control, and we have all this research telling us how important it is, we've got to figure out why are they burning 40.

Shanker – self-regulation model (3:11)

The heart of self-regulation is really the autonomic nervous system, and there are two systems that are counter-balancing each other, the sympathetic nervous system and the parasympathetic nervous system, and you can understand this in terms of a simple analogy: the sympathetic nervous system is a system that supplies energy to meet various challenges, various demands, the way the body works is that if the body's going to direct its energy to meet some challenge that the child is trying to master will say, that energy has to come from somewhere else, and typically what happens, and we know this now from some wonderful research done by say, Steve Borges, what happens is the energy gets re-directed from the systems that are regulating your internal states: your temperature, food resources, so all of that, all of those resources get shunted over to those parts of the brain that are going to deal with this challenge, well you can only do this for long before the body starts to suffer, you can only concentrate for a problem for so long, or try to deal with some sort of stressor before the body starts to get hungry or tired or, and the body sends out a signal: now it's time to stop, it's time to rest, it's time to recover, and that's when the parasympathetic system kicks in.

The parasympathetic system is essentially a braking system, and this is essential to restore the body's equilibrium. So we have these two forces that are counteracting each other: one is like a gas pedal and the other one is like a brake pedal; when a child is really self-regulating well, we call is optimal regulation, when a child is going really, really well, there's a sort of seamless shifting back and forth between these two systems- the body spends some energy and then it recovers to prepare itself for the next challenge, whatever that might be, when a child starts to get into an allostatic condition, it's a condition where the balance between these two systems is a little bit out of whack, it's because there's been too many stressors, the child is constantly putting his foot on the gas pedal, and because of that, constantly putting his foot on the brakes. Brakes, we kind of think of as having brake pads that can start to wear out, essentially if the child has too many stressors, then he's activating his parasympathetic system, his braking system, the inhibition system a little bit too much, and this can have long-term consequences, it can have long-term consequences for how well that child will respond to stressors, physical and psychological, throughout the lifespan.

Shanker – self-regulation, self-control and the brain (1:25)

When we study self-control, when neuroscientists study self-control, we're really interested in a fairly specific part of the prefrontal cortex, the medial prefrontal cortex. When we study self-regulation, what we're really interested in is the sort of flow between the limbic system and various parts of the prefrontal cortex. It could be the medial prefrontal, it could also be the dorsal lateral prefrontal or the ventral medial. But we have one specific system when we're looking at self-regulation which is the anterior cingulate cortex and by focusing on that it has two ends to it, two sides. When the child is in a state where they can in fact exercise self-control, the one side lights up. It's kind of blue on your imaging. When the child is in a dis-regulated state or what we call a "red brain state," the other side is. So you can actually see, you can actually study self-regulation and whether what you're doing is enhancing the child's calmness by seeing which side of this ACC is lit up. It's fascinating stuff to see.

Shanker – Shanker self-regulation method (3:17)

There are five elements and the five elements are reframing behaviour, so everything you and I have talked about. Distinguishing, for example, between misbehaviour and stress behaviour, between oppositional defiance and what we call angstbeisser, which is what a cornered animal does when they're threatened. So we have all these distinctions and they're very important and reframing ourselves, reframing my own impulses, recognizing that these distinctions that we're drawing for children are every bit as relevant for ourselves or whoever.

The second step is recognizing the stresses and really what we mean here is deepening our understanding of not just overt stresses but hidden stresses and often it's a sort of tandem exercise between reframing and recognizing. The better you get at reframing, the more you start to recognize. The better you recognize, the more you reframe also. Then we talk in the third step about reducing stress and so there are many, many ways of doing that. To give you a very simple example, if a child is finding it very stressful in a noisy classroom and this is one of our major stresses for little guys, there are very simple techniques for reducing the stress. We have used headphones, earplugs, a quiet area in the classroom, a quiet area in the hall. So there is all kinds of ways of reducing stress once you actually know what the stresses are and here we emphasize that every single child is different. So what's stress for one child may not be for another.

Then the next step is we talk about reflecting and really what we want the child to learn is we want them to develop their awareness not just of when they're over-stressed. We want them to learn to recognize when they're becoming over-stressed, when they're getting close to that point of being over-stressed in order for self-regulation, the last step, to be really successful.

The last step is responding. In order for the fifth step to be really successful, it's very hard to do much when you've gone past your point, when you've lost control or whatever, when you've had a meltdown. I mean think about the toddler who's had a meltdown. There's not much you can do at this point other than just soothe them. Is it possible to actually get a toddler to understand when they are approaching that point? Yes it is. Well if I can do it with a toddler, I can do with a teenager.

Shanker – stress behaviour vs. misbehaviour (1:40)

In our neural lab, we were studying the anterior cingulate and when the prefrontal cortex is in control and you look at the images, they're all blue. And when the child's in a state of high arousal and very little capacity to control impulses for example, it's all red. Blue brain referring to when prefrontal is dominant. Red brain referring to when limbic system is dominant.

Looking back at all the work that we did with the families, the one issue that came up more than any other is, "What exactly is this difference, this distinction between misbehaviour and stress behaviour?" So misbehaviour is, in fact, the blue brain behaviour and what that means is that the child was capable of acting differently, of making a different choice, that the child knew what he or she was doing and really decided to disregard the possible consequences. Stress behaviour is a red brain behaviour and stress behaviour means that the child had very little awareness of what he was doing or why, really did not choose to act the way he did and could not have prevented himself. These are really strong, powerful urges that come up from the limbic system.

Shanker – studying autism therapy and brain changes (2:05)

And when you think about it, that means that these kids are kids that have a lot of trouble with social interactions because also, social interactions revolve around what Stanley Greenspan and I call emotional signals. For example, facial expressions: with your facial expressions you're sending all sort of messages to whoever you're talking to that you're angry, happy, interested, bored. But the kids that we work with have a lot of trouble picking up this information; they have a lot of trouble attending to those parts of the face, the hands, the head, that we use to send these messages to each other.

So when we look at a typically developing child, we see certain parts of the brain lighting up as the child processes this information. And we are particularly interested, in our lab, in what's going on in the anterior cingular cortex. When we look at our children with autism, what we see is relatively little activity in those parts of the anterior cingulate that should be processing that information. Well for us, this was a tremendously exciting discovery because it gave us a sort of neurobiological benchmark that we could use, in addition to all of our behavioural measures, to see how effective the therapy is. So, we begin very intensive therapy, and we use a form of therapy developed by Greenspan called DIR and this is particularly useful for our purposes for two reasons: one is it is a therapy you can perform on very young children, preverbal children; and the second is, it's a therapy which focuses on the child's social/emotional capacities which are precisely the elements that we are interested in.

Shanker – studying the brain (2:24)

There was a dramatic breakthrough in the kind of research that developmentalists are doing a couple of years ago when Don Tucker created dense ray EEG which is a system that allows us to get a fairly in depth look at the cortex of fairly quite young children, in fact we can look at newborns. And the way you do this is, you have what is in essence a bathing cap that is dipped in a saline solution that you put on the child and you have either 128 or 256 electrodes that enable us through something called Source Modeling to get a fairly good picture at the way those parts of the brain that regulate emotion.

What we can look at is those parts of the brain that regulate emotion and see how these are interacting with the more cognitive parts of the brain. In our own research we are particularly interested, right now, in young children that have been diagnosed with Autism or Autistic Spectrum Disorders. And we give these kids a very intensive form of therapy and we want to discover two things. First of all we want to know is the therapy actually effective and the second thing we want to know is does the therapy produce measurable changes in brain functioning.

So, to do this, the very first thing we have to do is to get the kid used to wearing the bathing cap and with young children with autism this is certainly challenging but we've been, our head researcher Jim Steven, has been remarkably successful in getting these kids to wear the bathing cap. And then we want to see is there something distinctive about how they are processing certain kinds of information at the very beginning of the program, before treatment has begun. And we do see some striking patterns emerging now. One of these is that the children have a lot of difficulty processing emotional information.

Shanker – the Milton and Ethel Harris Research Initiative (5:21)

So in the year 2004, Milt and Ethel Harris created this institute: The Milton and Ethel Harris Research Initiative at York, and we had several mandates. Milt wanted this to be a state of the art developmental/cognitive-neural science institute. So the idea was that we would work with young children with autism, young children between the ages of 2 and 4, and we would look at the full spectrum of kids with autism. So not just high-functioning but any child, and we would use a method of intervention developed by Stanley Greenspan whose been my partner, was my partner for many years until he died a year ago. And Stanley's method is called DIR, and essentially the key to DIR is that you take teams of therapists to work with the child, and those teams will have a speech-language therapist, and occupational therapist, mental health specialist, psychologist or if necessary psychiatrist, nutritionist, and we do very intensive work with the child for two hours a week.

Now, the way the program works is that we are convinced that the key to helping these children learn how to self-regulate, and by learning how to self-regulate how to enter the social world, we're convinced that they key is mom and dad have to be the primary deliverers of this. So the way the institute works is the parents literally have to sign a contract, and the contract stipulates they will do a minimum of 20 hours per week applying the things that they learn with us in their two hour session, and in exchange they'll get free therapy for a year plus all of our tests, etc. When we started this we were very concerned about how parents would respond to, you know, this is a fairly demanding commitment on their part. In fact, our parents have done on average about 24 hours a week, you know it's close to 4 hours a day, every single day, and so we thought we better measure parental stress before, during, and after, because even if the program worked it wouldn't be a long term success if parents found this too great a burden.

And to our great surprise, not only have the children done extremely well, so what we've seen is that the kids to begin to self-regulate significantly, I mean, optimal regulation, and we see significant, meaningful changes in their social behaviors. We see significant, meaningful changes in their ability to initiate interactions, their ability to engage in shared attention, we see significant changes in their overall affect, their happiness, and basically they become happy, and they become committed with their parents.

Well what was happening with mom and dad, that was our other big question, and to our amazement, we saw a huge drop in parental stress, so even though they were doing all this work, their stress dropped, and their overall stress dropped, their parenting style starts to change, so what is going on here? What is going on here? Well, we've talked a bit about the sort of attitudes that we have to kids with various problems like obesity, or behavior, and once you start thinking in terms of self-regulation, you're really trying to understand what's happening with a child, you're trying to understand what's going on inside the kid. Why is the kid having this reaction and what can I do to ameliorate it, to avoid it or reduce the load on the child, you're starting to see you child with very different eyes, a different lens. You're not longer judging the child, you're not angry at the child; you're not seeing the child as being willfully non-compliant. Instead you're seeing that the child is having trouble staying regulated. The reason why we saw this is because of the work we did with our parents in the autism treatment program, as soon as; we had parent after parent telling us the same thing, as soon as they began to understand what was happening with their child, they

felt this enormous load being lifted off their shoulders. It was a load that was socially imposed. It was a load that came from, you know, having a child with autism in a society that frowns on the kid that, you know, behaves in a certain way in a supermarket because, quite simply, the child's been overloaded by the bright lights and the cold air and the hard floors in the supermarket, and so they could let all that go, and as a result their overall stress was dramatically reduced.

Shanker – therapy and caregivers (1:13)

So the more we understood this, the more apparent it became that whatever kind of therapy program we employed, had to be one that placed the caregiver at the heart of the delivery of the therapy. And there seemed to be all kinds of reasons for why the caregiver remains so important past this initial period of two years. Perhaps it's because, simply sort of a dose effect. The caregiver spends more time with the infant than any therapist possibly could. Perhaps there's a sort of intimacy factor, the fact that the child trusts the caregiver, but also that the child understands the caregiver's non-verbal signals, their non-verbal cues, far better than they understand anyone else's. Remember we all gesture in very subtly different ways. We use subtly different vocalizations, or looks on our face. So the child has a much better understanding of the caregiver's intentions than anyone else.

Skinner – DNA and epigenetics (2:46)

The DNA is made up of billions of little base pairs that come along and they come together to make up the DNA**.** There are genes spread throughout the genome and each gene sort of have slightly different functions in terms of the protein being produced and so forth in terms of what it does. And so essentially you have all these genes that come together that allow certain cell types to be a certain cell type, like a liver cell will be a liver cell and a neuron will be in your brain and be a neuron because of the certain sets of genes that are turned on at that time. And so that's sort of the way everything comes together going forward.

So epigenetics is defined as sort of molecular factors around the DNA that can regulate how the DNA functions and usually that means which genes are on and off or at certain times of development how they get turned on and so forth. But basically it's the molecular factors around the DNA that can regulate how the DNA functions completely independent of DNA sequence. It does not care what the DNA sequence is. If there was a sequence dependent then it would be genetics. The fact that it's epigenetics means it doesn't matter what the sequence is, so it's really two different things. And then basically when the epigenetics changes, it sort of regulates the stability of the DNA, how often it might get mutations, how it functions and long-term sort of how the genome, sort of all the DNA works. So it's molecular factors around the DNA that regulate how the DNA functions completely independent of DNA sequence.

Now we realize that the epigenetics can chemically modify things around the DNA, can totally silence a gene or turn on a gene, put it halfway in-between, and you'll have these different sets of genes not due the sequence of the DNA but due to the epigenetics around that sequence as to whether it gets turned on and off. And so essentially it is one of the major factors that regulate the DNA. And so just the sequence, just genetics, just the sequence we thought was going to be enough to do all that but now we know in today's sort of science that it's not. It's just a small piece of a much bigger story and with epigenetics and genetics together it works much better and more efficiently.

Skinner – epigenetic transgenerational inheritance (7:14)

So the question is how was it we actually came across the idea of transgenerational epigenetics? In other words, an epigenetic mark that occurs in the sperm or the egg that gets transferred for all subsequent generations to come, so it's a form of non-genetic inheritance. Normally we think about inheritance being a replication of your DNA sequence and it goes to your offspring through your sperm or egg and then that's what you inherited basically. Now we realize that an equally if not larger sort of field is epigenetic inheritance.

So the question is how we came across that idea. So you have to understand most big discoveries in science don't necessarily happen because someone thought about it upfront before they even got into it. It's usually a more serendipitous observation. We were studying the sex determination period when a testes or ovary start to develop in the foetus to determine whether it's going to be a male or a female. So I wanted to see what happens if this was interfered with. So we took an environmental chemical in a rat model. We used an outbred rat model, which is just a laboratory rat and essentially did the exposure during that sex determination period for the rat. And then essentially took this forward and the offspring were born and we looked for any kind of deficiencies or abnormalities in the testes or ovary in normal sex determination. It turns out we found nothing, so this is a really good example of a failed experiment. We did the experiment. We did the whole sort of thing. We got all the results and there was no effect on sex determination. So essentially the experiment failed. So the lesson is pay attention to your failed experiments. Because what we then did is we aged that animal out to a year of age and what we found is when they got to be a year of age we saw a whole bunch of the cells that are going to turn into the sperm, they started dying in the testes. Not all of them but there were a large number of them. So there was basically a reduction in sperm number and motility and basically – so when they became adults – so we published that study.

That was all fine and dandy and then what happened was several months later I had a postdoc in the lab. She came into my office and she was very upset because she accidentally bred those pups when they got older into the next generation. You have F0 mother we exposed, the F1 generation is the pups. So she took the F1 pups when they were old enough and bred them to get the F2, so the grand-offspring from the original mother. She was upset because we didn't plan that experiment and just accidentally did a breeding. So I said, "Don't worry about it. Just go look at the traits, look at the testes in these F2 generation animals". She did and she came back and said, "It's exactly like the first generation. Ninety percent of the males had this testes deficiency". So, of course, I didn't believe her and I made her go out and repeat it and we took it out four generations. And so essentially what we did is we found that at each generation for four generations 90% of the males had this testes phenotype. So that's when we realized there's something going on here that was outside the norm of what we were thinking.

Normally what happens in a genetic inheritance situation was you get a trait like this testes phenotype that may be 90% in the first generation. But then the next generation, as you bred it out, would go down to 50% approximately. And then the next generation 50% of that and so eventually within four or five generations you sort of have lost the phenotype or the trait. So, essentially, we didn't see that it was 90% for four generations. So this told me that there had to be some other inheritance phenomena going on that wasn't genetics. That's when it made me start thinking about epigenetics.

At the time the technology to study DNA methylation and epigenetics, this was sort of the late/mid 90's, it wasn't really good. But we did what we could and we could and we found that there was indeed a DNA methylation change. There was a methyl group on the DNA that was different across the genome and it was present in the sperm for the four generations. And so that was our first observation of this ability for the environment if it causes an epigenetic change in the sperm or the egg that this has the capacity to go forward for generations to come.

Only the F0 generation female was exposed. None of the subsequent four generations had any exposure and so this exposure was sort of causing an effect that was then transferred. The biggest activity be it for us and many of the labs that have come into the area is to try to figure out the mechanism for how this epigenetic inheritance works and we're gaining a lot of speed on that but we don't know all the details, but that's basically what's going on. It's the epigenetics in the sperm or the egg is being programmed and then it gets passed through development processes for each generation. And so this is this non-genetic form of inheritance called epigenetic transgenerational inheritance, which is now a very different thing from genetic inheritance and the environment, has the ability to dramatically modify this epigenetic inheritance and then go forward. And so the individual that lives in a certain environment or organism that lives in a certain environment versus another has a way to change its physiology and phenotypes of traits so that it can better adapt to this phenotype of this environment versus this environment. We've known that that process goes on for a long time. We just didn't know the mechanism and it turns to be epigenetics. And it explains huge amounts of things like how rapid evolutionary events occur which we couldn't explain with genetics, where potentially disease comes from, a change in the phenotype, where disease comes from. So lots of things we started to – we couldn't explain before, could be explained through this epigenetic inheritance.

So for epigenetic transgenerational inheritance, when the germ lines carrying what we call epimutations, these mutations in the epigenome which is – whether it's DNA methylation or other forms like non-coding RNA or other things, when those get programmed they're carried forward and that's the epigenetic transformation inheritance. So we identified it initially in rats. Subsequently, it wasn't more than a year or so then some people showed it in mice and so they thought 'well this is just a lab rodent sort of thing'. But then pretty much everybody that's looked in any species they've sort of studied thoroughly has found this phenomenon, and that covers plants, flies, worms, fish, birds, rodents, pigs, and humans today.

Skinner – epigenetics and twins (1:34)

Identical twins, which have essentially the same genetics, when they're very young and born they will look alike. They'll have the same health and so forth. But when they get to be about teenagers or a little bit longer or certainly when they become adults, each one of the twins get different environmental exposure. They may live in different places, they may have different exercise, their lifestyles will change a little bit. So over time then if you have 50 year old twins what's known is that the diseases that the two twins get are generally different. That's called discordant disease. The vast majority of identical twins do not have the same disease between the twins.

If biology was totally dependent on just the DNA sequence, then those twins should get the same diseases but that's not what we see. So those environmental influences, those lifestyle changes diet and everything else will slowly change the epigenetics around the DNA such that it changes what genes are on and off and the physiology of the different tissues so that eventually you'll have a higher susceptibility for this twin to get maybe obesity and a higher susceptibility for this twin maybe getting arthritis when they get old enough. So essentially those discordant diseases is not due the DNA sequence but the environmentally changed epigenetics.

Skinner – moving beyond genetic determinism (1:36)

There's a paradigm in science called genetic determinism and the concept is that the DNA sequence is basically the determinate for everything, it's like – I've heard of your genes determine who you are, and so this idea is that genetic sequence allows certain genes to get expressed on and off, certain genes get expressed on and off. This changes how the cell functions tissues function and eventually the biology of the organism. If there's a mutation in the DNA then essentially you'll have an abnormal gene expression, abnormal physiology and abnormal biology and this is where we thought most disease came from.

Today what we're moving towards is a slightly different concept in that's where our epigenetics will actually come into play to regulate how that DNA functions. So it's not so much the sequence, it's really the epigenetics will allow us much more elegant control for what genes get turned on and off and then that will actually cause disease, health or whatever; this genetic determinism focus that's been there for 100 years. It was actually started with Mendel, sort of rediscovery of Mendel in the early 1900's and so we've been studying it for a long time. It's been really critical to get us to where we are now, and genetics is absolutely important; but the epigenetics turns out to be a newer paradigm where it comes and works with the genetics in terms of how things work, much more different sort of going forward.

Soderstrom – 'Many Baby' study (3:03)

So what we're doing right now is this is part of a much larger study where babies from lots of different language communities were tested on their preference for infant-directed speech and all of the original study was done in English infant-directed speech. And now we're testing babies in other languages like in this case Norwegian. There's been a big change in how we think about doing infancy research. So in the old days it was each lab was doing its own little research project and you'd have, you know, it's very hard to recruit infant participants and it's hard to run those studies. So we'd have these very small samples and it's just really hard to know when you're comparing across studies, one that was done in Winnipeg and another one that was done in Paris, when you see differences, whether those differences have to do with the differences across those populations or across the languages or the ages of the babies or something about the differences in how the methods are run across the different labs. And they're also really small samples which can limit our ability to interpret what we find.

So there's been this push to collect data in a much grander scale where we're sharing our procedures across different labs. In a study called the Many Baby Study that actually is close to 70 laboratories who were all collecting data for the same project. So we can look at differences that have to do with subtle differences in how you run the method or differences in language or age at a scale that you just couldn't do with these sort of individual laboratory tests. When you're running a study that is international and large scale like this one of the challenges is to figure out if because it's a language study what language you're going to actually do the test in. So in general about – I'm not sure of the exact numbers but somewhere probably around 90 percent of published studies are in North American English. So there's this huge bias in our understanding of how language development works towards the peculiarities of the English language. And our European colleagues are always, for good reason, complaining about this. So when you do a grand study you want to be cognizant of those biases but at the same time because you're trying to base the research on the literature that's existing, you know, you don't want to sort of randomly do a study in Norwegian without understanding how that fits in with the existing literature.

So the original large scale many baby study was done with the English language but now we have this problem that we've now reinforced that bias so that now there's an effort to do some of the same – to kind of repeat some of those tests with other languages to expand on our understanding of how this works not just in English but also across languages which is really, really important.

Soderstrom – message for parents (1:23)

I think that the take-home message is that infant-directed speech or kind of the funny way that we talk to babies is definitely not bad. You know, sometimes there's a message that gets out there that you shouldn't talk baby talk to babies and I don't think the literature supports that perspective. There's a lot of good reason to believe that these characteristics and how we talk to babies are important and there's a robust literature supporting the idea that the more you – the more babies get in terms of language input, especially sort of that one-on-one kind of interactive experience, is tied to language development, so it does make a difference. But I always temper that a little bit with this knowledge that there are differences. There's individual differences and there's cultural differences in how we interact with babies. And I would never want a mother to feel that you know, I must talk – I must engage with my baby all the time or I'm harming my baby. It's just something like anything in parenting that you know. It's good to interact with your baby. It's good to turn the television off. You know, it's good to read to your baby. But it's not something where you know, you don't want to make parents feel like they're – you know, they must be on all the time for their babies. People are real human beings. They live their lives and there's, every family has its own style.

Soderstrom – methods for studying infants (1:38)

There are a lot fewer studies these days that use sucking procedures. Those are usually done with the really young infants, so newborns or first few months of life. And typically, again you would associate the sucking with a stimulus, so a sound or a visual display would appear when they suck. And when they – sometimes it's directly measuring like the faster they suck, you know, the more of the stimulus they get. Sometimes it's more of a criterion where if the sucking goes to below a certain rate then something would change. So it's done in a couple different ways with the sucking procedures.

I think part of what's going on is that the visual measures with eye trackers have become so much better than they were even a decade ago that the eye-tracking techniques have kind of taken over even with very young babies where sucking procedures and also brain imaging techniques as well although they're much more expensive.
The sucking techniques require a lot more training. Maybe not than the brain imaging. But the sucking techniques require a lot more skill and training and sort of the equipment setup is more complex than some of the – especially the newer eye-tracking packages that are fairly plug and play. So I think there's kind of a shift that's happening in the research community away from the sucking techniques and there just aren't as many labs that are sort of trained in those methods anymore.

Soderstrom – moral choice study (4:56)

So this was a study that was originally developed by a researcher named Kylie Hamlin and what she was able to show was that infants would prefer shapes that were behaving in a way that was kind of a nice way of behaving over shapes that were behaving in a mean way. So it was a way of being able to show that fairly young infants have this some sort of degree of moral understanding.

So in this case what we do is the babies come in and the mother just closes her eyes so she doesn't see the visual display. And the baby's sitting on the mom's lap and then there's a visual – a video of a shape trying to get up a little hill and then you have two other shapes. One of the shapes is kind of pushing the original shape up the hill. That's the helper shape. And then there's a hinderer shape that pushes the shape down the hill. And then after they've accumulated a certain amount of looking to the videos and after they habituate to a certain amount to the videos to show that they've gotten what they want to out of it, then we do a test where we actually present a live three dimensional choice for them of the helper and the hinderer shapes and see which one they prefer to touch. And that's actually a really challenging thing with babies, especially the younger babies who might be reaching with both hands. So there's quite a careful articulation of what counts as a choice.

of course, it's very important in these studies that the infant's preference is not based on a preference for a triangle or a square but actually based on the videos that they were watching. So there are a number of things done to prevent those biases. One of them is that they – when the original shapes were designed there was a lot of work put into making sure that they were equally salient or interesting to the babies in terms of their colours and their size and everything. And then in the design of the experiment, we make sure that for some babies it's the square that's the helper and for some babies, it's the triangle that's the helper. And also, the researcher is blind to which shape is the helper or the hinderer in that particular study. So in fact, we don't even know which, whether it's the square or the triangle that was helper or the hinderer until after we do the data analysis. It gets recorded by the computer but we don't look at those data until all of the data have been collected.

And then since that original study emerged there's been attempts to replicate it. Some of them have been successful and some of them haven't. So this research endeavour now is trying to do a larger scale replication because this particular protocol is actually really challenging to do and so when other laboratories were having trouble replicating one important possibility is just that they weren't doing it right. So Kylie is – and some other researchers like Kelsey Luca and others have been sort of championing developing the protocol in a way that lots of laboratories can learn to do. And so you can have a much larger scale replication effort where people are actually being trained by the original researchers and we can see can this – how well does this replicate outside of those original laboratories.

Soderstrom – studying infant language preferences (3:46)

My name is Melanie Soderstrom. I'm an associate professor here at the University of Manitoba in the department of psychology and I run the baby language lab which is an experimental research lab with infants where we look at how babies learn their first language. We bring babies into the lab and we play speech sounds for them and then we measure their interest in what they're listening to and we use that to learn about what they understand about language, what they prefer about language.

The first study uses a method called the head-turn preference procedure and the idea with the head-turn preference procedure is that we associate the speech sounds with a visual stimulus, just a visual display, and in the old days that was actually a flashing light. Now we do it – usually do it with video screens and so it's a flashing circle that changes to a checkerboard pattern and it's just a way of measuring what the baby is interested in listening to. So if they turn their head the speech sound plays. If they turn their head away after a certain amount of time the speech sound stops and the babies learn really quickly that they can control what they're listening to.

So the baby comes into the lab. They're seated on the mom's lap. The mom is wearing a set of headphones that play kind of a weird mix of music and speech to try and mask what's being played so that they don't accidentally influence the baby's behaviour and that's really important. And then the experimenter is in another room so they also can't hear what's being played and again bias things. And then when the baby's looking forward the screen on the side comes on. The baby looks to the side and then it changes to the checkerboard and we play the speech and like I said, as long as they're looking towards the screen the sound plays and if they look away the sound stops. So the longer that they look towards the screens the more interested they are and so we can compare different types of speech. So in this particular study, we're looking at baby's interest in something called infant-directed speech. So the way that we talk to babies that's different from the way that we talk to adults.

So it's been known for a number of decades that we speak differently to babies than to adults. And so there's been a lot of research looking at the different properties; the fact that we use a higher pitch and a more variable pitch; the fact that we speak more slowly and with more of a happy, positive affect and a number of other characteristics. And there's a lot of research supporting the idea that this is actually beneficial for babies in learning language. And then together with that, there's also a growing body of research that shows that babies prefer to listen to speech that's in that style versus in the adult-directed style which is kind of more monotone and longer sentences and things like that. So they're hearing speech that's in this infant-directed speech mode and other speech that's more directed at an adult and we look to see whether they prefer the speech sounds in infant-directed speech over adult-directed speech. In this particular study, the speech they're hearing is Norwegian because we're also looking at differences across languages and language communities in infants' preference.

We're measuring the length of the looking time on a given trial and if that looking time is longer then we interpret that to mean that the baby prefers that speech stimulus than if they look for a shorter period of time. But obviously, we can't get into the baby's head and this is an inference that we're making. This is one of the things that makes research

with infants much different from with adults or even certain aged children where you can actually ask them, Hey, do you like this or do you not like this?" We have to make these inferences based on their behaviour and what can babies do. They can suck on things, they can look at things, they can grab for things. So those are the things that we measure.

Soderstrom – studying the impact of SES on language development (3:23)

So there was this original study called Hart and Risley. That was the authors' names. So the Hart and Risley study was groundbreaking in a sense that it was looking at the impact of socioeconomic status on the language experiences of infants and the original finding was that there were differences in the quantity and the type of language exposure that infants from different socioeconomic backgrounds were exposed to and this was correlated with differences in their vocabulary development. And so this was calculated and the term was coined the 30 million word gap and it's had quite an impact in our thinking about how to address social disparities. And so that was done with the research methods of the time and in fact, it was somewhat groundbreaking in – I mean it's a huge – I think sometimes people underestimate the amount of effort that was put into painstakingly hand transcribing all of those many hours of recording and so, you know, sometimes people criticize it was a small sample but gosh, there was years of effort that went into producing that result.

So that was kind of a seminal finding. Since then there's been quite a lot of research looking at the impact of socioeconomic status on the experiences and the language development of infants and there's a general consensus that there is an impact of socioeconomic status. What is driving that is, of course, the question. And so more recently there's been a debate that's emerged in the field around how we characterize and how we understand the nature of children's language experiences.

So one of the things that's kind of this thing that we're trying to resolve is that on the one hand, you have this very robust set of findings about differences across socioeconomic status. On the other, you have these very strong cross-cultural differences in what's considered sort of normative behaviour between mothers and infants and we know of communities around the world where the idea of spending time talking directly to your children has – you know, that's just it's very different. There's the – if you measure it there's just very little actual directed speech that children are in these sort of one-on-one context. And at the current state of our understanding of these things there doesn't appear to be any reason to believe that those – children from those communities are disadvantaged when it comes to language development. So, on the one hand, we have this robust literature that says that the amount of speech and the quality of the speech that you hear is directly tied to your vocabulary development and measures of language development. On the other we have these massive cross-cultural differences in the quantity and the types of speech that infants are exposed to and bringing those two literatures, these two robust literatures and understandings together in a way that paints a coherent picture, we're just not there yet.

Sokolowski – biological mechanisms of epigenetics (7:25)

We used to say it's about DNA methylation, adding a chemical mark to the DNA sequence, which changes the expression of the gene or the gene product that's made. But now we know that epigenetics comprises a lot of different biological mechanisms that affect how much of the transcript, that's the RNA transcript, or how much of the protein is going to be involved in any given process.

The epigenetic mechanisms that are studied, that is studied the most in mammals is CPG DNA methylation, and it puts a mark on the DNA sequence and that mark is a little methyl tag, a little chemical tag. And depending on where that mark ends up, if it's near the start of a gene it can turn down the way you use a dimmer switch in lighting, it can turn down the expression of that gene, it can turn down how much RNA the gene makes.

And so it's been classically studied from the perspective of people who have a lot of stress or trauma. And genes involved in coping with stress like the genes involved in the glucocorticoid pathway are looked at and there's methylation marks that end up in the promoter of the glucocorticoid gene which turns down the amount of transcripts or RNA made, which has later consequences for how we cope with stress, our immune system and our health and longevity.

That's only one type of epigenetics, and there's other types of epigenetics that are important and have been studied more and more in the last few years. And from an update perspective one of those types is called histone modifications and here you have always the DNA sequences wrapped around these proteins called histones, that's now it normally lives, and those histones, the DNA wrapped around and they're all tightly together.

I used the analogy of the DNA sequence being like a hair and the genes being beads on a string so now that DNA sequence has wrapped around these proteins and by that wrapping it all gets very, very much condensed and tight together, that's how our chromosomes look under a microscope, we don’t see a full DNA sequence.

So when that DNA sequence is very tightly wrapped is a very hard for the genes involved to have their DNA transcribed into RNA. In other words gene expression is also turned down. And what happens is that the DNA is wrapped around these histones and now instead of the methyl or chemical tags going on the DNA sequences, as in DNA methylation, they're added onto the histone tails. And here again depending on the type of tag you can have DNA expression turned down or turned up. The one that we study in my lab is a certain histone methyltransferase that represses gene expression. And just like with DNA methylation depending on where it lives, that mark, it can affect the expression of the gene. So it's like DNA methylation, histone modification, but instead of modifying the DNA it's modifying these histone tails of the DNA's wrapped around.

It is important to know that when it comes to gene expression it's not just one mark, there's a landscape of different epigenetic modifiers sitting on that gene and near that gene. And depending on what that landscape is, the gene will either open itself to be transcribed to make RNA or it will close itself more tightly. And when it opens itself there's

something called transcription factors that come in to start the transcription of the DNA and those transcription factors are the things that responsive to the environmental experience. And so when you have the DNA really tightly coiled there's no room for those transcription factors to come in, bind the DNA right before the start site and make the RNA. The main point is that in the past we thought there was just one epigenetic modification, the DNA methylation and now we know there's many, all acting together on a gene with different environmental inputs affecting which ones go where and what the output will be from that gene. We also know that these DNA methyl marks are not only right next to the gene affecting gene expression but they're also found in places we can't really understand all over the genome and we don't know what they're doing but we want to understand and that's something for the future.

The third kind of DNA of epigenetics is micro RNA and they're also starting to be studied and these are just tiny little RNA sequences that attach to any RNA that's made and kind of sop it up so it can't be used. So these little RNAs are affecting, making these gene products not at the level of the DNA to the RNA at the level of transcription, but at the level of what we call translation when the RNA gets made into a protein.

And these micro RNAS are particularly interesting because they target lots of different classes of genes. So one little mark micro RNA can reduce the expression of genes involved in the sleep or cognition or stress responses or neglect for instance. So, they're a way to study how a whole process might be modified epigenetically so that the genes are changed according to experience. So it could be how sleep deprivation influences cognition, that's one of the things we study in my lab. Or if you have sleep deprivation some people need to catch up when they don't get enough of a night's sleep and other people are okay. And these kinds of things are regulated by lots of genes but there's also these epigenetic modifiers like these micro RNAs that are fine tuning the expression of lots of genes involved in that process. So those are the three things that are now mostly studied, the DNA methylation, there's different types, some make the lights less on the dimmer switch, some turn up the lights, here the lights mean expression. There's histone modification which does much the same thing but it's not on the DNA sequence, it's on the histone tails, the little marks. And then there's micro RNAs that are being studied because they seem to be important, kind of acting in a hierarchy high up affecting lots of other genes. And there may be more that are still being discovered so it's not that DNA methylation as we thought was a mechanism for nurture. There's many different epigenetic ways that our experience gets embedded in our biology and now we're trying to understand that.

Sokolowski – cell differentiation (1:06)

So all the cells in our body have the same DNA compliment, and any individual arises from one sperm and one egg, and all the cells have the same DNA except for sperm and egg that have half. And so one question is: how is it that we end up differentiating how is it that some of our cells end up as liver, some as kidney, some as brain: And this has to do with how the environment around the cell talks to the DNA in that cell. So some of the DNA for some of the genes gets expressed- when you're making a liver cell, and other genes get expressed when you're making, for instance, a brain cell, so that's within an individual how there's differences in gene expression that give rise to different kinds of cells. The DNA is the same in all cells but the gene expression, the proteins that are made are different.

Sokolowski – gene (1:33)

A gene is a very long piece of DNA, so each of our chromosomes have long pieces of DNA, like a very, very, very long hair and it gets wrapped up together and that's our chromosome. And when we look, stretch out that long piece of DNA and divide it up, there's genes that are made of that DNA, so at one part of that long hair is the beginning of the gene, and one is the end of the gene. So the gene is a piece of our DNA and they're along this hair like beads on a string, and each of our chromosomes have a series of genes that are on them. And those genes may encode for, may contribute to differences in eye colour, differences in whether you have a hitchhiker's thumb or not, I don't, you can look at your thumb, some of them bend back a little more. Whether your earlobes are attached or not, whether you can roll your tongue, which I can, others can't. And so these genes can influence variation in those traits, and so you may have a gene that influences one of those traits, like whether you can roll your tongue or not, and that's one gene that is encoding tongue rolling, and one person may have one variant or one form of the gene, which is to roll your tongue, and one another may have the other variant of the gene, which is to not roll your tongue. And so for traits like that, the gene in a way determines the outcome, but for most other traits: behavioural traits, developmental traits, there is not a one-to-one relationship between the gene and the trait.

Sokolowski – gene by environment interaction (2:22)

So gene-by environment interaction is, because of those differences in the alleles, you have different sensitivity to the same environment. So you have one environment, that let's say is an adverse early environment, and one individual that has a certain form of that gene is really not affected by that adverse environment, and the other is highly affected. So for the individual that isn't affected this is like the child who can move from place to place, family moves, different situations, lots of stress, and they seem to do okay. Whereas the other child that has early adversity, is highly sensitive, the gene expression, the amount of protein that gene makes with that particular DNA polymorphism, the gene expression is altered in that case and the child is highly vulnerable, But if you water that child carefully and you nurture it, the child will do exceptionally well, but if that child experiences a very bad adversity early in life it's very hard on them.

So genes contribute to sensitivity or susceptibility to environmental adversity, also to environmental enrichment. We're not just talking about adversity here, and so it's useful to think about enrichment because we don't want to focus on problems or diseases, we want to also focus on promotion and prevention, so promotion of good health.

So gene-by environment interaction is when you have different alleles or forms of a gene and they respond differently to the same environment. Now you could also build it in and say well, we have different environments, and poorer and a better environment and you could ask how do those individuals perform. Now of course it's more complicated than one gene. There are many, many genes in the genome, over 20,000 in humans, and some genes have larger effects than others. And that's where we can pull out the effects of certain genes and say, for instance, the serotonin transporter gene is important for sensitivity to the environment in certain situations of early experience, but it is also the case that other genes are also important.

Sokolowski – generational epigenetic transmission (5:15)

So one of the exciting possibilities for epigenetic modification is that it may be inherited from one generation to the other, I don't mean inherited in the DNA sequence but the patterns in the way that the chromosomes were wrapped up or marked are inherited. And this would have to be somehow in the germ line, it would have to be in the egg or sperm or both of the parents, because that's what's continued into the next generation and Art Petronis who's a professor at the Centre of CAM-H, Centre for Addiction and Mental Health in Toronto, has recently taken sperm from humans and shown even from one man that the sperm have different epigenetic markings on it so there is some evidence that sperm can be differentially modified. So there is some evidence coming along that it could be that some of the patterning, if you've had a stress as a child and then you have your children, children could pass on the problem that your genes have with being able to cope with stress, so that's one idea.

The other way that it can be translated from generation to generation has to do with a kind of cultural transmission if you like where, and Michael Meany at Mc Gill has shown this with his high and low-licking mother rats and so in this situation you have a distribution of behavior for a mother rat. So mothers look after their babies by licking and grooming them, and people have said this is synonymous to how humans look after their babies. We don't lick and groom our babies but we cuddle them, talk to them, touch them. And so the touching from the licking and grooming is similar, and certain mother rats tend to exhibit high-licking and grooming. So they would be at the high end licking and grooming continuum, and others exhibit low levels of licking and grooming. And when Michael takes those mothers and then looks at the babies, if the babies when they become mothers have had experience of high-licking and grooming, they tend to be high lickers and groomers. And similarly, if the low-licking and grooming mothers have babies that have been low-licking and groomed, and they have babies, they tend to be low-licking and grooming. And so that information alone doesn't tell you whether this is due to genetic polymorphism, or a kind of epigenetic process. But he did a cross-fostering study where he took two pups from a high licking and grooming mother, and put those pups in with a litter that was with a low-licking and grooming mother and then he did the opposite. He took two pups from the low-licking and grooming mother and cross-fostered them with the high licking and grooming litter. So you have a pup that is from a high-licking and grooming mother that was "genetically" from high-licking and grooming. And then you ask "what does that pup do when she's a mom?" and you find that the main thing that matters is what your foster mom did. So if you were high-licked and groomed, whether it was your biological mother or your foster mom, you will be a high-licking and grooming mother, suggesting that it's like a kind of, it's due to the environment. il's a cultural kind of inheritance. It's not, there's not a genetic explanation for it, and he has shown that this is epigenetics.

So you can have grandmothers that were very high stressed, and had low-licking and grooming compared to high. And then you can give mothers, mothers who were all high-licking and grooming right, or all in the middle, and you can still see some carryover from the grandmother in some cases. So, in other words, how much is going to be transmitted in this cultural way, and how much can be modified depending on experience? We don't know.

And so there is evidence that it's translated from generation to generation. We don't know the biological mechanism, if you look at epigenetic marks, which are methylation patterns we all have them, twins differ in them, we all have them, and it isn't that they're totally stable through your life either, they come and they go so it's very new. And in humans it's very difficult to study because unlike mice and flies we can't take a part of the brain and say "well, what's happening in that part of the brain?" We have to use blood, and when we talk about gene expression it changes depending on what tissue you look at so the blood, information from the blood may not be at all representative of the brain. So, there's suggestion that these things can be translated but the biological analysis of it is still, I would say more work needs to be done. And the thing to keep in mind with epigenetics again is it's not fixed, so epigenetics is not deterministic, just like DNA variation is not deterministic, and you can enrich and change the epigenetic marking.

Sokolowski – nature vs. nurture controversy (1:49)

So now we know that it is not nature alone, and it is not nurture alone, and we can't even add them together and say, "well it's 30% nature and it's 70% nurture" that is also wrong. What it is, it's an interaction between nature and nurture, and interaction between genes and the environment, and that's an interplay between the genes and the environment, and I'll talk to you more about how the environment, the genes are listening to the environment, and that's what we mean by epigenetics - the genes are listening to what the environment is doing. And as a result of that listening more or less protein is made.

So one thing that we need to wipe out of our thinking is deterministic thinking. We don't talk about a gene for this, or a gene for that, and if you read in the paper that there's a gene for being violent, someone has quoted the scientist wrong or the scientist was describing their research wrongly. And the work that we've done in my lab really shows that even in the cases where we have a single gene, we've identified it, we cloned it, we know there's two DNA variants. It predisposes animals to behave differently, all we have to do is alter the early environment of those animals and we completely change the gene expression, and also the behavior. So the allelic variation does not have a fixed effect in any way on the phenotype. And we can also go in later in life and boost up the gene expression in animals, and cure, or if you like - or restore the more normal behavior or that level of behavior. So that's what the common, modern day way of thinking - it's about gene by environment interactions, the nature/nurture controversy is dead.

Sokolowski – research (2:53)

So, that's hopefully helpful to have shown you the difference between gene-by environment interaction, epigenetics. Gene expression is involved in both, we have differences in gene expression because of gene-by environment interaction arising from differences in the DNA sequence, and how they respond or are sensitive to the different environments. We have differences in gene expression, epigenetics, arising from essentially the DNA being covered up so it cannot be expressed.

This new science of gene by environment interactions and epigenetics is at its infancies, at its early stages. It's hugely exciting because of providing us an explanation if you like for nurture, and the interactions between nature and nurture, or genes by the environment. But in terms of the biological mechanism, it's really at its early stages, and it's, I would say, too early to translate this directly. There may be some implications but we don't, for instance, want to go into the school and check the genes and say this kid should be on this regime or that regime. I don't think we would actually ever be in that situation. On the other hand, we do have these exquisite individual differences between children, and we may be able to understand more about their background, and more about their pre-dispositions. How stable are these epigenetic patterns? We know they're stable but to some extent, do they last for a lifetime? People have said that this adverse early experience sets this path for later health, learning, functioning in society. We know that if you've had early adversity, you have a higher chance of heart disease, obesity-related problems, obesity. But not everyone has that, just like there's some individuals who are smokers all their life, and so we want to understand those individual differences.

So the stability of those marks, those epigenetic marks, and how they translate from one generation to the other is not known, and then finally what is really not known is how the DNA polymorphisms interact with the epigenetics from a biological point of view, and that's happening as well. So we would like to have an understanding, of an environmental landscape- how it changes through time, how that environmental landscape interacts with the genetic, the genome, which is, the genome means all the genes, and then how they interact together to create neural circuits that interact with the environment. It's a huge job but we're getting there and it's probably, it is hugely exciting.

Sparling – educational program (1:03)

We believe that the results of this study, especially the first Abecedarian study and the big one we did on low birth weight children are the results of the educational program. That is the elements I talked to you about what happens in daycare. The reason we believe that is because we were careful for the kids who didn't get into the program, the ones who were in the control group, to see that they had good health care, to see that they had good social services to make sure that they got nutritional supplements for example during the first years of life such as iron fortified formula and so forth. Those elements that we tried to equalize out across the two groups, and that really makes us believe that the effect was much more reasonably associated with the educational program.

Sparling – health findings (1:57)

One of the unexpected findings of the Abecedarian program is that when we measured at age 21, there were a variety of health outcomes. Children were healthier, they were less likely, oh, no, they weren't children anymore, they were young adults. They were less likely to have symptoms of depression.

They were more likely to have a healthy diet and a healthy lifestyle. They were less likely to use drugs and they had less risky behaviours. Now that was not something that we targeted, but I think what it shows is that if your life is going better in general, if you're succeeding in school, if you manage to go to university or a substantial proportion goes to university, then the odds of your taking care of your health, of having better health outcomes just increase. It was kind of an indirect effect and we're rather intrigued by that. When we study at age 40, we're going to look especially to further health effects because many of the groups we've studied have predicted poor health outcomes as they age, and so we think that may not be so true for this group.

There has been one economic analysis happen of the Abecedarian program and it basically shows that for every, when we measure at about age 21, for every dollar spent there's about a four dollar return to society, and that, by the way, is largely from the educational effect. We haven't even begun to get the health effects of that so when we go further out to older ages, it's very likely that those numbers will go up in terms of the return on your investment.

Sparling – outcomes (2:38)

The Abecedarian studies have over the years taken IQ as one of the important measures that we did. It's not that we believe that IQ is such an important variable over other variables, but it's known to relate very well, very strongly to school success. If you manage to be a little smarter, you're likely to do a little better, and it's kind of a measure that predicts how kids are going to do in school and in life, and we have been able to see for example in the very first study and in the study I mentioned for you about the low birth weight babies that the IQs of the children in the experimental control group diverge rather quickly and between 18 months and 24 months, somewhere in that period of time, the two groups become significantly different so that one group has an IQ advantage over the other, and by age three, the difference is quiet large, quiet striking. Now in the groups that we have followed for a long period of time, such as the original Abecedarian group, when we measured IQ at age 21, which is the last time we measured it, we still had a significant difference. By that time, it had been about a 15 point IQ difference, it was only about five points by that time. The groups has kind of merged together, but the difference between five IQ points meant the difference in terms of going to university of a 23 per cent graduation rate for the experimental group and a six per cent graduation rate for the control group. In other words, a fourfold increase.

Now, what's interesting about this, remember this is a very at risk group. Twenty three per cent University graduation is what Canada has for the general population. It's what the United States has for the general population. It's what Australia happens to have for the general…this is a very at risk group, and that's their graduation rate. It just shows that just because you were disadvantaged; you came from a poor family or poor neighbourhood, you don't have to do worse than the general population, and I think that's very good news. It shows that early childhood can have a lasting effect, not a small and temporary effect.

Stanley – nurturing (3:19)

Well this is where I think it's very exciting because we now know more about brain development and child development than we ever have. Of course we used to have it intuitively. When I talk to some of our Aboriginal researchers and colleagues, the equivalent of your First Nations people, they say, "Why are you researching this? We've know about this for 40,000 years." And my answer to them is: We seem to have forgotten it. We seem to have forgotten how important those early years are to develop the knowledge and capacity to interact with peers, to have a capacity to understand your environment and to be able to be competent within it. And to actually have these wonderful social interactions that enable you to be an intellectually and socially competent person. We have forgotten how important those early times are. When you think about it, it's logical. It's so logical.

But what's been very important and exciting is the neuroscience research, the brain research, which has shown how incredibly important the brain development is, both in utero, in the womb, and in those first three, four, five years of life. While there's obviously quite an important genetic component for the big picture of what a brain looks like, we all have cerebellums, we all have a cortex, we all have an amygdala, we all have a temporal cortex and so on. But how those parts of the brain work together and actually become competent in utero, in those first few years, are due to those social environments around a child. It's that sensory input; it's about how these peers, these parents, these environments around that child; auditory, visual but also the ones that turn on the frontal cortex, particularly the nurturing environments, the appropriate response to crying, the breast feeding, the reading to the child, the talking, the really stupid things you say to a child, which is in fact developing that child's understanding about how social interactions occur. And in fact we know now that that turns on specific neuro-endocrine pathways in the brain. It's wonderful stuff.

So that gives us a very strong message about the importance of these interactions and teaching parents about these interactions. They're not just inconsequential; they are vitally and centrally important to how that child will be at age 10, at age 20, and even at age 50 and 60. And so this now is where the solutions come in. That we have to provide for parents, for communities, for families, for governments, local, state, that's your province, and federal governments, this knowledge. Because the whole future capacity of that child, that family, that community, that nation, is dependent upon how effective it is that we turn on these pathways and make these brains connect properly. Exciting. Simple. Gorgeous.

Suomi – alcohol abuse (2:22)

This is work done in collaboration with my ex-student and now long-term colleague Dr. J.D. Higley, who's a senior scientist at the National Institute of Alcohol Abuse and Alcoholism, Alcoholism and Alcohol Abuse, it's NIAAA. And Higley and others have devised a technique where they provide monkeys in their familiar social group or sometimes, in some studies, in strange situations, but typically in their own normal social group, and with the opportunity to participate in what you might call a monkey happy hour, where for an hour a day over an extended period of weeks or longer, these monkeys have access, unlimited access to eight or nine percent alcohol solutions sweetened with Nutrasweet or aspartame, a non-alcoholic beverage sweetened with Nutrasweet or aspartame and plain tap water. So these monkeys are not fluid-deprived in any sense. And most monkeys do not, like most humans, don't initially like the taste of alcohol; the sweetness. And under these circumstances some monkeys will consume considerably more alcohol than will others. Again, in exactly the same situation.

And what we found is that there are both genetic factors and early experience factors that predispose some monkeys to consume more alcohol than do others. And we also see interactions between these genetic and environmental effects. So most spectacularly, what we have been able to demonstrate is that monkeys who carry a particular variant of the serotonin transporter gene, what we call the short allele version of that gene, if they are peer-reared, these monkeys drink alcohol to excess. But if they have good mothers, those monkeys with the same short allele, short version of the serotonin transporter gene, actually consume less alcohol than do others in their peer group. So what appears to be a genetic risk factor for excessive alcohol consumption for individuals with poor early environments or less than optimal early environments, may actually be a genetic protective factor for individuals who carry the same gene but who have very good early experiences. And this is a perfect example of what I would call the gene-environment interaction.

Suomi – foster mothers (3:24)

Well, we have two sets of findings. One that was done some years ago before we knew specific genes that might be involved, taking monkeys that were genetically shy and fearful, and these are monkeys that under normal circumstances develop patterns of behavior that look very much like the behaviorally inhibited children that Jerome Kagan has been studying for the last two decades. These are individuals who, under challenging, under normal circumstances or familiar circumstances show perfectly normal behavioral and physiological patterns, but when they are exposed to model or moderately stressful circumstances, they show excessive amounts of fearful and anxious-like behavior; they show heightened arousal of a variety of physiological systems including the hypothalamic-pituitary-adrenal axis, evidenced by higher levels of cortisol, ACTH and CRF, a high unstable heart rate; greater norepephrine turnover; and some compromising of the immune system. These monkeys, who make up about 20 percent of the population in the wild and in our colony, also are at risk for developing depressive behaviors if the challenge they are exposed to is more extreme, and later in life they show excessive consumption of alcohol.

When we carried out a cross-fostering study, we took these monkeys whose genetic backgrounds suggested that they were going to develop into this bio-behavior phenotype, and we put them with unusually nurturant foster mothers that we call super moms. These were females, multiparous females, whose care of their own previous offspring indicated that they had very, established very firm and secure attachment relationships, they were very supportive of their infants' exploration, they showed very low patterns of punishment, and when we cross-fostered our high-reactive, as we called them, infant monkeys to these foster mothers, we were quite surprised because the up-tight monkeys, as we characterized them, actually showed supernormal development. They were behaviorally precocious, they actually explored more than their counterparts. During the weaning process they showed lower levels of disturbance and distress behavior in reaction to their mother's punishment and they became unusually adept in social situations of seeking out help when they needed it. So they were, became very good at establishing functional social relationships with others in their social group. And ultimately they rose to the top of their group's social dominance hierarchy, whereas high-reactive infants reared with normal mothers or cross-fostered to normal mothers usually end up at the bottom of their group's social dominance hierarchy. And most interesting to us, when the females, high-reactive females who were cross-fostered by the super moms, grew up and started having kids of their own, they showed the same patterns of maternal care that they received when they were infants. Thus they were capable of passing on the advantages that they had accrued from their own foster mothers onto their own offspring.

Suomi – maternal buffering (2:26)

Well, because we're able to determine the genetic background of our monkeys and describe, and indeed, control their environmental histories we are in a position to see whether there are so-called pure genetic effects and whether there are so-called pure environmental effects. And indeed, when we do straight forward analyses like those, yes we find that most, many of the things that we're studying, both behaviorally and physiologically, have highly heritable components and they clearly can be modified. These patterns can clearly be modified by differential early experiences. But when you run analyses that take both into account, what stands out is that pure genetic effects and pure environmental effects are the exception rather than the rule. And instead what we see is interactions between these effects so that individuals who have the same genetic background but grow up in different environments turn out quite differently and individuals who have different genetic backgrounds but are in the same, grow up in the same environments, also have very different outcomes.

And indeed, these fall into some very interesting patterns and perhaps the most interesting pattern is a pattern of what we call maternal buffering. Over and over, for many behavioral and physiological variables, we find that individuals who carry genes that would put them at risk to have less optimal outcomes under relatively poor environmental circumstances; when those same at-risk monkeys grow up with good mothers they turn out perfectly normally or in some cases even better than the so-called normal Rhesus monkey developmental trajectory.

And so we're impressed by the fact that good mothering can allow individuals who carry genes, to carry genes that would otherwise put them at risk to continue to carry those genes and indeed, pass them on to the next generation but with no obvious behavioral problems. On the other hand, if something happens that compromises, in nature, a mother's ability to take care of her kids that have, carry those genes, then a variety of problems will emerge. And so this is why we talk in terms of maternal buffering as one of the primary driving forces behind the gene-environment interactions that we're able to observe and document.

Suomi – aggression in monkey play (1:37)

Well, Rhesus monkeys, as they are growing up, as do most primates, engage in a great deal of play behavior during their juvenile years. This behavior takes a variety of forms and there are interesting gender differences that emerge very early, just as, that parallel gender differences that have been reported over and over again in studies of human play. In particular, males tend to engage in rough and tumble play; the monkey version of a wrestling match, if you will. Whereas female monkeys show much less contact in activities in their play and instead prefer chasing games and patterns of affiliation. So if you look at the play patterns, males not only play a little bit more than do females, they play more physically and more roughly.

Also, very quickly on, these monkeys, when they're in mixed-sex groups, begin to segregate themselves by gender in terms of their play partners. Basically it seems to be a consequence of the fact that a male will play with just about anything that moves whereas a female usually will not respond to a rough and tumble play initiate from a male but will readily respond to an initiate from a female. So basically females are choosing partners and males are left with only other males with whom to play. But the developmental course, emergence and developmental trajectory of these gender differences are virtually identical to what you see in human children if you take into account the fact that the monkeys grow up four times faster.

Suomi – NIH primate studies (4:17)

Well, the laboratory, the primate laboratory that NICHD helped me build is in rural Maryland about 40 kilometers outside of Washington, D.C., in the countryside, where there's plenty of space. And so we're able to have some of our colony of Rhesus monkeys housed outdoors in multi-acre enclosures that simulate their natural habitat and allow us to have them grow up in social situations that are equivalent to what you find in the wild. We also have monkeys growing up in smaller housing pens but that still allow for relatively normal socialization. And we have a neonatal nursery where we hand rear infants from birth onward and then socialize them with peers or our artificial mothers and peers before integrating them into the larger social group. We have our own self-sufficient breeding colony so that we can basically, through selective breeding, control the genetic background of our animals and we're able to control various aspects of their rearing environment. For example, whether they grow up with their own biological mothers or whether they are foster reared by unrelated adult females or where they grow up with no parents but with access to peers.

And we're able to study these animals longitudinally, essentially throughout their entire lifespan, which for Rhesus monkeys in captivity can go as long as 30 years or more. And we also, because it's essentially a captive colony, we can sample biologically either saliva samples or blood samples or cerebral spinal fluid samples, at any point during development for all individuals. And before and after certain environmental events such as introduction to a new social group, removal from an existing social group, exposure to novel toys or things such as that. So we are able, basically, to control the genetic and backgrounds in environmental histories of our subjects and this gives us an enormous advantage over those who are trying to do parallel work at the human level. Because we can watch these animals essentially every day of their life, rather than only periodically, such as every three or six or nine months that's typical in most human studies, we can actually see developmental changes occur before our very eyes, rather than having to guess what's happening in between sampling periods. This also is an enormous advantage over most human development studies.

And finally the fact that our monkeys grow up four times faster than do humans allows us to see a generation in four or five years instead of having to wait 15 or 20 as would be the case for humans. So these advantages allow us to address directly questions that are of considerable importance at the human level but which for practical and ethical reasons are often difficult to study directly with humans and that's the mission of our laboratory.

We also, I may add, have access to two field sites. That is, sites where Rhesus monkeys are free-ranging in wild or semi-wild conditions. One of them is an island off the coast of Puerto Rico where 50 years ago a group of Rhesus monkeys were brought over from India and their descendents have been thriving ever since. These monkeys are essentially undisturbed except for an annual roundup by the veterinary staff at the Caribbean Primate Centre who runs that operation. It's at that point we can get biological samples from these monkeys and we can watch them as we do with our own colony throughout the year. And we have access to another semi-free ranging colony that lives on a sea island off the coast of South Carolina.

So we are able, with this range of environments, to study monkeys in natural habitats, in our best efforts to replicate a natural habitat where we have some control over who's in that group, and under somewhat more restricted circumstances in the lab that still are able to provide certain essential components of what a Rhesus monkey's world is normally like.

Szyf – intergenerational epigenetic changes – epidemiological evidence (1:42)

So absolutely, stressful experiences of a parental generation can pass through such a mechanism to the offspring generation, and maybe down to the grandchildren generation. And there's epidemiological data that suggests that this could happen. I mean interesting examples are the Dutch famine during World War II that now phenotypes are being seen in the third generation of mothers who were exposed to famine when they were pregnant. There are other examples where we have multi-generation transmission of responsiveness to stress. I believe it's also an adaptive response because once environment changes, you want to send that signal down the line, life has changed and therefore we need another kind of genomic response to the environment. So perhaps it's a mechanism by which one generation can send signal to the other generation.

However, when the anticipated environment and the real environment are not the same, that becomes maladaptive, and you can get disease. So stressful behaviour is very useful in a war situation and adversity situation, but becomes useless in a peaceful situation. So when we have a misfit between the programming and the real world, then we have trouble. So we believe that disease is also associated with this process, but when there is a misfit between the adaptation and the real environment.

Szyf – intergenerational epigenetic changes – two mechanisms (1:48)

There is some evidence that epigenetic marks can pass down the generations. And there are two really mechanisms how it can work. One mechanism is behavioural inheritance. For example, rats that were low licked by their mothers will become low licker mothers, and we know there are epigenetic marks that go with it. These marks are not inherited by the sperm or the egg, they're inherited through the behaviour of the mother. So we believe that certain behaviours are inheritable through the behaviours of the caregivers or the environment. They will stay for generations causing marks not in the germ line but the behaviour of the environment.

There are other kind of marks that don't require the presence of the caretaker but are mediated through the germ line. So it is possible to change not only the DNA methylation marks in the brain, but also DNA methylation marks in sperm. The big question is whether stress can cause changes in methylation marks in sperm. One can think about ways that that can work through hormones that can go from the brain to the sperm, to the testes, and then this is passed to the next generation, and because these marks have a property, thy can be propagated, they can be replicated. That can now be passed to different tissues, and remain in different tissues. This is a way by which one generation can send information on experiences to the other generation.

