Session 1 Brain Development and Readiness for Learning Transcript

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ML Hi, I'm Mary Ellen Lewis and I am co-instructor for Neurobiology and Learning Differences with Dr. Martha Degler, and we are doing the first of several videos that are going to accompany your Power point lectures for this course online. The first one is about brain development and readiness for learning. I'm going to start asking you, Martha, about this early development – in utero development – and all the processes that are occurring – the cellular migration, the myelinization and the pruning – and what is chief among those things and the importance of this developmental period?

MD Well the reason why we have such a prolonged time in utero and we come out with such a big head relative to the rest of us is because a lot is going on prenatally. I'm not going to talk about the very basic part of development but the part the gets us towards cognition and learning.

First of all we have a whole bunch of cells that are deep in the central part of the brain that have to migrate out to the cortex. Now when people start asking me how many nerve cells there are it's like the Federal budget; its billions and trillions and big numbers that most of us can't really even concentrate on. I'm sure in your reading these numbers will be written down, but just think of a very large number of neurons – more neurons than you're going to have in many areas when you are considered fully developed. So you are having all these neurons migrate and they migrate along sort of fibers that are called glial cells and they are guided to their targets by a whole lot of chemical signals. There's a new article practically every week in the neurology literature about this protein or that protein that is suddenly becoming very prominent in getting cells… I wouldn't even worry myself about trying to memorize the names of the different chemicals, but the main problem is that these chemicals obviously are delicately timed and so if there's something that interferes with any one of them it may interfere with

the signals for nerve cells getting where they're supposed to go. But luckily 97% of these cells that migrate do get where they're supposed to go. Now 3% could end up not necessarily getting where they're supposed to go and they form very subtle clusters of nerve cells that we call malformations. If they were on your skin you'd just think it was a birthmark and wouldn't be very worried about it but if they form little balls of nerve cells that were not properly located they could cause varieties of troubles that we'll get to in another lecture.

So we have this process of cellular migration that is guided by other types of cells that aren't neurons themselves; they're also guided by an ever-increasing catalogue of different chemicals that make these signals. Then when they get where they're going they have to sprout their axons which are the outgoing part of the cells… and your Power point that's entitled "Getting Connected; Time Sensitive," gives you the names of these things. The point is that something that's called a synapse has to be formed between the axon and a dendrite, so the axon is the outgoing, very long, projected part of the nerve cell. Think of for example a cell in the cerebral cortex that is going to control your big toe; it has to get all the way down into the spinal cord, this one axon, before it makes a synapse. That gives you an idea of how elongated these sections of the brain can be, and the dendrite is the part that receives the messages. Everything is very activity dependent which means something's got to be happening and we know now that things are happening in terms of experiences even when the baby's brain is in the mother's womb. A very critical period is the middle trimester of pregnancy for all of this migration for getting to the cerebral cortex which for education, while not the exclusively important part is certainly the most important part of the brain that we're talking about forming.

So the stimuli are going on and they are actually already determining the strength of certain connections. The baby is moving; the baby is sucking his thumb; the baby is thereby increasing motor connections and it's also hearing, and think we've learned so much in very recent years about the auditory input to the baby's brain. We know that babies are hearing their own mother's intestinal rumblings

and a heartbeat, but also the mother's voice, so as you get to the last trimester of brain development that mother's voice is becoming one of the most specific things that the baby has already learned to discriminate from other voices, so that's a pretty startling thing how much of this auditory connectivity is going on in the baby's brain, and maybe that has some implications that we have to do some more research on.

[5:48]

ML Also you mentioned earlier when we were talking about the fact that just because infants in utero can hear, this idea of playing classical music and all that is really not something that should be stressed.

MD Yeah, I think… this is sort of a general…

ML It doesn't necessarily guarantee cognition.

MD …principal, you know. It's like the people that thing because vitamin D is good enormous doses of vitamin D are better; this is not always true. As a matter of fact sometimes too much is a bad thing, and not that I'm saying Mozart necessarily will cause poor brain development but there's no sort of absolute linear relationship between listening to the Mozart and having a better wired up brain. Certainly it would probably be a good idea that the baby be in an environment where there are human beings talking back and forth. We don't know anything yet about what it would do if there were total silence, or what would happen if people were yelling at each other? We don't know; this is a whole fruitful area for research. The point is that stimuli are already in the game and it's not just a predetermined, "Oh, here's a glial cell, that's a guidance cell, and here's a chemical," and that's it – that the environment is always shaping the brain even before you're born; that's the big take-home message, so learning is going on even in utero and learning is a way that the brain is created. That's a pretty awesome thing for teachers to think about.

ML I agree. In all this development I think that threats are there and what do you see as the main threats as children are developing? They're approaching school age… Kids have a long time in many cases before they actually go to school and they might have five years of development before they actually go into a school environment. Fortunately a lot of youngsters now have preschool environments – nursery schools or even daycare facilities that have educational goals and preschools that are really designed to prepare you for kindergarten. But as this development is going on what would you describe as some of the threats that might have impact later in life?

MD Again I think… we just established what I would call the "Goldilocks Principal" which is not too much stimulation and not too little stimulation but just a nice, moderate amount of stimulation. So I think that over-stimulated environments may cause a failure to prune the noisy connections in the brain so that maybe you don't achieve a sufficiently efficient set of connections. On the other hand we all are quite acquainted with the idea that if you locked a child in a room and did not converse with the child the child would not only have emotional problems but would not learn language. So too little is terrible – we know that. I think we have to worry though about too much and particularly premature too much because we may create all kinds of, shall we say, overly-surviving connections that create noise in the system and we may create some strange, anomalous rerouting of connections that we wouldn't like too much either. In other words once we have the cells established we should go back and realize that the next thing we have to do is prune the cells and the connections that are not being used, so we have to be careful to think what are the ones we want to be used as a preschool child-rearer, whether you're a teacher or a parent, and not introduce as I said too much noise into the system or too much excessive demand for something that is not at the proper level of development to be done with the right connections. So you might be using, as I said, inefficient and in a way harmful connections.

The other process I should go back to is you start with this myelination in the last two months and myelination gets increasingly important postnataly; it's like

insulation of wires and speeds the signals. There's a very special electro-chemical reaction that goes on as you transmit information along pathways in the brain. Before you're even born your motor system and your sensory system get myelinated, but there's a very prolonged post-natal process. The myelination of pathways for language is of course of great interest to us, but I think the one that we're going to come back to again and again is that myelination of the real command and control part of the brain, which ultimately is the frontal lobe, continues in human life until you're in your early thirties so I know that people have happily been reading lots more in the popular press about how brain development goes on until the mid-twenties; that's true for cognitive issues and of course we all know that the insurance companies for automobiles have long recognized that there's something special about age twenty-five when your insurance premium can kind of settle down to what's called "adult levels." They don't do it at eighteen, but for what we think of as real self-regulation and self-control this process that begins prenatally in the motor system and the sensory system doesn't get to the real connections – the wiring up of your ability to not display emotion, not let emotion be in the center of your behavior at all times – that doesn't really normally settle down until your early thirties, so I would say in neurological terms instead of the old 1960's thing about "don't trust anyone over thirty," I would say be a little bit careful about trusting somebody who's under thirty because they don't have fully developed brains. So just about the time that most people were thinking that they would get to be grandparents is when their children are going to have fully mature brains.

ML I think we were also agreeing there's a reason you can't run for certain offices until you're thirty-five.

MD Yup, that's very excellent folk wisdom that people just observed that there was something about age thirty-five that probably brings you up to the, you know, standard deviation of which thirty-two is the mean for the myelination of the frontal lobes.

[12:46]

ML One of the other things that's in the power point presentation which I thought was something to stress, because in education we have the constant discussion of boys and girls and should they have separate groupings at times in their development; not for reasons particularly related to boys and girls in terms of behavior but their learning, and you mentioned in the lecture about the boy brain and the girl brain, so can you talk a little about these gender differences and when they are most concerning and when they seem the most apparent?

MD Actually there's very well-established data that from twenty weeks – that's half way through the time in the womb – girls are 20% more mature than boys in their brain development. Everything happens 20% faster. I always like to point out that by kindergarten that means that the girls are a year ahead of the boys since 20% of five years old is a full year. And this goes on until puberty. Now the thing where nature even sings out is of course that boys don't go through puberty as early as girls… they have about a two-year lag, the boys do, so if the girls are ahead of the boys… let's say they're a year ahead of the boys in kindergarten, that their brain development tends to plateau as they go through puberty and become fully mature, reproductive adults, and for most girls that also means they stop growing in height; their brains also stop being pretty much ahead of the game; everybody then sort of gets on an even keel two years later when the boys go through puberty approximately two years later than the girls – it can even be later than that with a certain chunk of boys. So the boys are behind the girls most importantly in the beginning of education which is interesting because most of the time, particularly when we went through a lot of women's issues thirty years ago, we thought oh, we got to worry about this falling off of girls in whatever it is that boys and girls start looking at each other as potential… of interest, and we thought that the girls needed to be separated at that stage from the boys because they would be worried about appearing to be too smart to be asked out on a date and all that sort of ramification.

But actually from a strictly biological point of view the boys are the ones that I worry about the most being disadvantaged in the K through elementary school

level because they are being asked to do the exact same things… for instance handwriting… I've done research on motor coordination development and I can tell you that all the motor coordination norms for five-year-old girls look like you picked them up and superimposed them on the distribution curve for six-year-old boys. So you're also in an era when we're asking kids to do things earlier and earlier. Many of the girls are going to be able to do it and the poor boys are going to be that much more behind the demand curve. So that's why we have to think very hard… Of course I believe in differentiated instruction for everybody so rather than saying you have to put people in a separate classroom I would come up with different solutions for that; I don't think segregation of the genders is necessarily the answer. But I do think we should keep in mind that we are really asking too much of little boys in terms of just about everything.

ML That brings me to the next thing that had to do with… you were mentioning it a little bit earlier that we are drawing down the goals we have for kids almost to the preschool level. Some of the expectation is youngsters are going to be reading fluently by the time they're in first grade, showing their decoding skills to be mastered earlier, a demand for socialization skills, a demand for early writing skills – all of these things that we just discussed in terms of developmental differences and motor differences as well as just cognitive differences. So what are your thoughts about the way we are dropping our expectations down as demands, because it's not just a demand on the student, which I think is unfair, but it's a demand on the preparation for teachers who are, as you're saying, recognizing all these individuals and their different needs which requires a way of planning instruction that represents this, but then to drop the demands for this academic preparation so low that four-year-olds are being asked to do what we used to expect of five-year-olds or even six-year-olds. What are your thoughts about that; is there an end point?

[17:51]

MD I think we've pretty much hit our heads on it right now because I agree with you. Many, many systems are just declaring that the first grade curriculum is expected

in kindergarten; they put in all-day kindergartens which means the children are staying in school longer and they say well since they're there longer we will have them learn more. This means that kindergarten gets pushed back to the pre-K year and…

ML If they go to school that year.

MD Yes, but there are increasing numbers of systems, I must say, that do have pre-K's put into their… I know New York City has pre-K's in all their school systems… But the logic is a bit, shall we say, detached from biology because the reasoning – I've heard this recently in a speech by the Secretary of Education say other school systems around the world are achieving more in math and science and so the next thing they say is so we have to start earlier. But this is not consistent with the biological reality that you may be dropping seeds on soil that's not ready to be planted; it would be like going out into your garden now when we've had a hard freeze overnight and deciding this is when you're going to grow your annuals. You're not going to be very successful.

They problem is that they confound perhaps the nature and intensity of instruction at appropriate times with starting earlier. The idea is if you start earlier then it means that you're going to, let's say, do algebra earlier and then you're going to do everything earlier. The only thing you should be doing earlier that you're not doing as far as biology is foreign language learning. Instead of our rushing to teach reading and writing… writing is particularly pernicious to start too early – I'll take a minute to explain that – but when you push those things you're not likely to get good results whereas the brain is absolutely just ready to soak up languages at this preschools stage and if we learned foreign languages and we used music to help us, because children are often very responsive to music, we could be getting a bunch of children who have excellent turning of their ears and their mouths to foreign languages and then not spend that much time on foreign languages and initial study in the higher grades and that would free up our time for more mathematics. So there are more logical ways that we could shape the

curriculum to take advantage of developmental readiness and windows of opportunity in the human brain.

So the writing is something I have a particular interest in. I hope to return to this in another lecture but these long fibers that we have to myelinate that go from our motor cortex down to, in the case of writing, our fingertips, they have a variable time at which they really become myelinated and it could be as early as three in rare cases, to as late as seven without there being any disability or anything other than just simply normal variation. And if you insist that everybody at four writes his name and writes the alphabet you will end up with compliant little children who are not really using the proper muscles to write with and who write with essentially their hands or their arms, but they're not able to give the signal to their fingers which is the really efficient way to be writing is with your fingertips, just stabilizing your hand and using your fingertips.

And then you learn another problem and fact about the brain and learning is that motor learning is extremely resistant to change. We're all delighted about this when we discover that after a twenty year interval we can get on a bicycle and still ride because we learned it as children – that's a good side of the hardiness or stubbornness, if you will, of the motor learning system, but it's exactly the opposite if we insist that you perform an action with what essentially are the wrong muscles and you get stuck with it. You'll walk around and you'll see adults who are still jamming the pencil into the space between their thumb and their forefinger and if you look at the movement the movement is of the hand, not of the fingertips. Now of course you're going to get more crampy and more tired and you're going to go more slowly, and that will stick with you right up to as long as the world expects you to be doing hammering. So that's an example of where you could call it "killing with kindness" where you start doing something earlier because you think you're going to get a jump on academic attainment and you're actually handicapping someone with your earliness.

ML I think preliminary skills like language skills that start with oral language are much better where youngsters learn appropriate names for things to build their

vocabulary, and I think this is where the issue is prior knowledge command and I think most teachers would say they recognize the deficiencies of students who come in with a lag in prior knowledge; they don't have the experience with things, with places, with objects to name them properly, and so it limits them in their conversation, and so building oral language first, because we learn to speak and all the other language arts sort of follow from hearing and speaking, and then actually as adults we probably do more speaking and listening again because it's more efficient. And yet when you look at how we emphasize things I think we sometimes are, as you were pointing out, we're sort of a mile wide and an inch deep for some things when we could… and I think core standards, the attention to core standards is going to change some of that. I know the National Council of Teachers of Mathematics has really entertained limiting math concepts and having more in-depth study of them and I think probably English and language and foreign language will do the same.

MD We're finding for example your very good point about knowledge and vocabulary that this resurfaces in comprehension and we find these children who seem to be meeting benchmarks for their ability to exercise the basic reading skills of using phonics and even through reverting to sight words, and then we get to the comprehension challenges and we find that there isn't the whole set of associations with the words that they're reading so the words are meaningless to them; they might as well be the nonsense words that we put on the decoding test. So it's really essential that we go back to the actually well-documented developmental literature that didn't even depend frankly on being a neurologist. But there is a great tendency to set that aside and to think that if we just rush in there and do it… And I think it's a misunderstanding of what are the real foundations of learning and that learning to read, yes, there's a procedural part of it that has to do with the alphabetic principal, but the broader basis for reading is the oral language that you eventually have to tap into to comprehend what you're reading.

[25:52]

ML Right, and to see language as something represented in more than textual ways; it's more of a graphic system.

MD Right.

ML Certainly we use a large number of icons to communicate regularly with people who speak many languages having the iconic system that we have for many functional things. I think that we don't do nearly enough in the development of oral language early.

MD Right. Now I just want to carry through a little bit more on development and just emphasize again… We emphasized that the frontal lobes which are absolutely essential for being in control of yourself…

ML Yes.

MD …develop later but the adolescent brain has come in for a lot of interest recently. I think it's important to emphasize biologically the enormous reorganization of the brain as the brain goes through puberty. One of those is the change in the biorhythms with respect to sleep and the fact that we have major challenges about getting adolescents to get enough sleep in order for them to be in a proper state of readiness to learn in school, so that's a biological change in the brain. Also as these hormones come in they actually increase synaptic pruning which means what you're using is much more critical; the use to lose ratio so to speak is accelerated I the teens. That's one reason why if you haven't been speaking a foreign language before then it's very highly unlikely that you're ever going to have a really good accent; it isn't that you can't learn the language but the speech part starts getting pruned away and so the ability to really sound like a Spanish speaker or sound like a German speaker is vanishing by the time most people get into that space. Also there's this surge of what I call bottom up stimuli from the emotional part of the brain. There are parts of the brain that are very sensitive to the hormones and there's this risk of an imbalance between having your cerebral cortex bombarded with these hormonally mediated messages about impulses and your ability to clamp down on them, so the bottom up, top

down traffic, if the synchrony of those developments are off – and later in this course we'll come back to certain children who are given certain diagnoses – but I think in a sense all adolescents have an impulse control problem. That almost sounds like a truism but it's still well worth understanding that it does come from brain development and that that period of time as children are going through puberty is just as much of a confusing time in the brain as when they're two years old, and many of the same oppositional issues come up again. The only trouble is that you can't pick them up and put them in their room as easily when they're going through puberty as you could when they were two. But it is the time of what we call "blooming, buzzing confusion" in the brain.

ML In trying to draw this to a close one of the things that is part of this course is what we call the Big Question, the TBQ for each one of the lectures, and so as a result of listening to what we had to say today we'd like to draw your attention to the first prompt TBQ that's in your syllabus and on the ELC and that is the question of why do teachers in the twenty-first century need to have knowledge of this brain function, brain dysfunction information in order to be competent teachers? And so not only looking at the lecture power point but hearing this video discussion this might help you form your opinion that you're going to pose about why the modern teacher, and why the training of the modern teacher, has to encompass this neurological development and all the information about how children differ from each other – sometimes from disability, sometimes just from lagging.

I hope you've enjoyed this and we'll be talking to you again for lecture two.

[End]