Developing Brains-
Ideas for Parenting and Education
From the New Brain Science

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Brain Science Meets Early Childhood Development-
A Timely Convergence

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Introduction:

The period of the 1990s was called the Decade of the Brain. We began to learn about how the brain functions and how it develops. Today, in the 21^{st} century, we are beginning to more clearly understand the *implications* of what we are learning. I believe that concepts of brain development and brain function MUST be woven in to everything we do with children – (actually, into everything we do, but my focus in this article is on young children). Understanding how the brain works illuminates behavior, theories and practices, and it shows us "in bright lights" where our attention MUST be in terms of supporting young children.

Students and scholars of child development are in a "prime location" - so to speak - for the convergence of brain science and early childhood. We are at the cutting edge of where the research meets practices. Brain science is reinforcing and supporting concepts of development that we already know, and it is providing us with new "principles" of development and learning- on which we can build practices and curriculum.

This new perspective on human behavior and learning is <u>especially</u> profound for the field of Early Childhood Education, because we work with children in the *first* years of life, when the brain is still rapidly developing its basic structure or architecture.

This article will present some key concepts or principles of brain function and brain development and apply them to examples of theories, practices, and educational philosophies from Early Childhood Education. The approach that I'm going to take is to answer the question: **"What Do We Know So Far?"** Let's start with the first and most basic concept of all.

Concept #1: The brain develops itself.

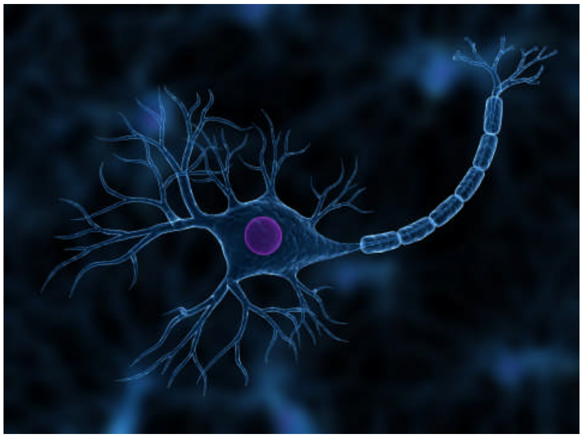
When we began to get the soon-to-be, revolutionary, neuroscience findings in the 1980s, those of us who were in the fields of Early Childhood and Child Development at that time began to learn about the development of the brain itself. We talked about the potential of *influencing* brain development in children through practices, relationships, and curricula. But, when we spoke of brain development, we had only a vague idea of "how" this was happening. What, actually, makes the brain develop?

Well, what we know is that "the brain develops itself". We know that this is directed by genetics, by the DNA that is in the cells of the brain, and we also know that it "develops itself" based on input from the environment, predominantly after the baby is born.

When conception occurs, the original cell starts dividing and replicating itself, creating a ball of cells. In response to a signal at about 18 days, the ball of cells creates a "neural plate" in the location of what will be the midline of the back, and it then begins to fold in on itself, forming the neural tube. At the top of the neural tube there is a "bulb" and this becomes the brain. The "tail" of the neural tube becomes the spinal cord.

The inside of the neural tube will become the ventricles of the brain (the "holes" in our heads!) where there is cerebrospinal fluid. The cells that are next to the cavity of the neural tube will create the cells of the central nervous system.

It is this *very early* stage of brain development that is being addressed through the commercial addition of folic acid to bread products, because a lack of folic acid in the mother's diet is linked to the development of such neural tube defects as spina bifida.

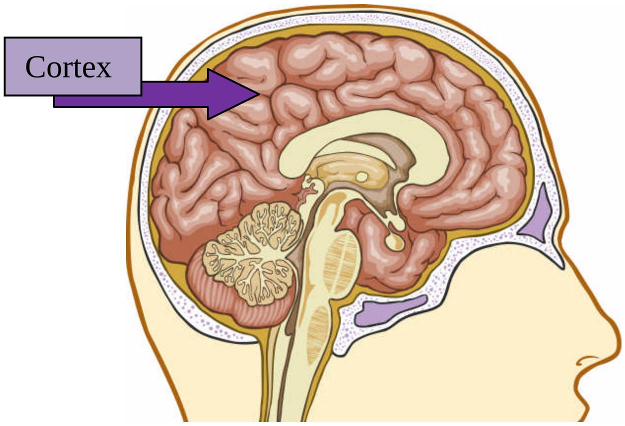


Drawing of Neuron by Eraxion

Neurons are the communication cells of the brain, which eventually connect up to each other in dense networks and neural maps throughout the brain.

After neurons are created, some of them begin a process of migration to get to the location in the brain where they will become the cortex, the outer layer of the brain.

These migrating cells have an address and a job. This is one of the ways that the brain grows itself, grows its structure, based on a pattern laid down in the DNA. The cortex (the squiggly part that we can see on the outside of the brain) grows itself like an onion, in six layers, from the inside to the outer layers. By the time the baby is born, the brain is ready to go, but… it will not stay the same.



Drawing of Brain by oguzaral

The baby's brain is designed to adapt.

In fact, the brain is the only major body organ that is not done developing when the baby is born. The brain has its basic structure, but it needs to "find out" what it has to know, what it needs to be good at in the environment into which this baby has been born.

The baby's brain is *ready to learn*. However, this new brain's development is vulnerable to *both* under- and over-stimulation. It needs "just" the right amount of stimulation. An example from the development of the baby's sensory systems will illustrate this by looking at how the brain both creates itself and protects itself.

When babies are born, leaving the protective and nourishing womb, they come out into a world of intense and constant sensation: lights, sounds, smells, textures, touches, tastes. However human adaptation has favored an *immature* eye at birth, with an outcome of protecting the newborn brain from being *overwhelmed* by an onslaught of too much sensory information. Too much bright light can harm the developing brain. A full term newborn's vision is thought to be fuzzy and like looking through a cardboard tube, dampening down the amount of light allowed to get to the occipital cortex in the back of the brain where vision happens.

As the eye matures, it allows for a gradual increase in visual stimulation to reach the brain, which has already begun its process of adapting its architecture to the specific visual-cultural environment in which it is located. In other words, the brain *learns* how to "see" through stimulation of the visual sense, through "looking". This connects with and provides support for the work of Jean Piaget and his description of the first stage of cognitive development, the Sensori-Motor Period, which states that babies develop their first cognitive schemas through sensory stimulation and action on the environment. Sensory input <u>changes</u> the brain.

Now, cultures each have unique ways of "seeing" the world. So, in addition to learning how to see in a technical sense, the baby also is learning *what to look at* and *what it means* from his parents and others who interact with him. We'll look at this in more detail when we get to the frontal lobes.

Over-stimulation

For a baby who is born early, before his due date, he comes into the world of sensation with a brain that was promised more time in that dark, muffled, and fully supportive environment of the mother's body. Preterm babies, who have to be in the intensive care unit of a hospital, are having their very immature brains subjected to more than typical sensation, with all the lights and noisy machines and people of neo-natal intensive care!

There is ongoing research that is looking at how this bright and noisy environment might give the immature brain too much stimulation, causing disruption in brain development. Currently, about half of all babies who are born early will have learning problems that will show up when they get into elementary school. Many hospitals have already put procedures into place to reduce the noise and lights of the hospital for pre-term babies, thus protecting their brains from over-stimulation.

Under-stimulation

In the case of under-stimulation for developing brains, babies, for example, who have chronic ear infections in the first year of life, may run the risk of language and speech delays or disruptions due to the lack of clear hearing during this critical period in brain development when the brain is learning to hear. Likewise, babies born with a cataract must have it removed very early in order for the visual cortex to get the stimulation it requires to ever be able to "see" out of that eye. The newborn brain *requires stimulation* to finish developing itself, not too much and not too little, *and*, at just the right time.

There is an interesting fact about the development of vision that makes a good transition into the next part of how the brain develops itself. At birth, although the baby's eye is immature, the baby *is able* to see objects that are the same distance as is the face of their parents and caregivers when they hold the baby in their arms. They are touching each other and looking at each other, ideal for bonding and attachment!

Culture is transferred person to person

Bonding and attachment are critical for another major driver of brain development postnatally. This is the structuring of the brain through the passing on of the human culture to the next generation. For this, the brain needs continuous interaction with other people…more precisely, interaction with the content of their brains in the context of a warm and loving relationship. This relationship puts the baby in the best state for learning!

When a baby is born, the people who surround that child begin to *transfer* the cultural information they know (their language, their perceptions, their values) to this new human. In this way, the new baby does not have to "discover" all the accumulated human knowledge of our entire history in what would be a "hit or miss" manner. Instead, we deliberately expose the baby to the sights, sounds, smells, and people of their world, and the baby's brain modifies its architecture accordingly.

For the brain to continue to develop itself, the baby needs to learn what is known to his parents, relatives, and other people. During the first year of life, for example, a hearing infant will strengthen the connections in the hearing centers of the brain that process the sounds that are in his culture's language. At the same time, it will discard the brain connections it would have used for other sounds unique to other languages. The baby starts out able to discriminate – to hear – the sounds of any of the world's languages. But, through interaction with his caregivers, the baby's brain strengthens the connections for the sounds he hears, and "prunes out" connections for the sounds he doesn't hear.

DNA lays down a "boiler plate" structure for the brain that has way too many connections and even too many cells. Once the baby is born, the baby's brain begins to modify and adapt its structure based on the experiences he or she has in the world, *especially with other people.*

This modification happens by strengthening and adding connections between neurons that are used, as well as by "pruning" away connections that are not being used. In this way, using the case of language as an example, the baby learns what sounds to pay attention to, and which ones to ignore, and gradually begins to associate meaning with the sounds. Thus, the brain has been *significantly* changed by 11-12 months of age.

The brain, then, is co-constructed through interactions with other people and within multiple environments, which is consistent with the work of Lev Vygotsky. We modify our brains to learn the language of our family.

We even become familiar with and prefer the tastes of our family's diet -- because we drank our mother's milk, which, in turn, was flavored by the food she ate! So the environment that we grow up in will determine the specific connections in our brains, with all the details and complexities and meanings.

The whole process of the brain developing and modifying itself takes about twenty years – from birth to early adulthood. Then the brain stabilizes its structure and makes more minor (though constant) modifications throughout adulthood, based on experiences. We never stop learning and so our brains never stop changing. In fact, it appears that even the "aging brain adapts to its own decline." (Reuter-Lorenz and Mikels, 256)

Now, let's go into a little more detail.

Concept #2: Use it or lose it.

What we "do" gets transformed into neural circuits in our brains. Neurons are connected to each other at a tiny gap, called the synapse, where neurotransmitters are released. (It is somewhat of an oxymoron to say that where these cells connect to each other is at a gap – or a space, but that is the situation.) These neurotransmitters that are released from the end of the neuron's axon will stimulate receptors on the "next" neuron (or neurons), and those will stimulate the next and so on.

Each time networks of neurons activate-- the connections between the cells become stronger and the connections increase in number. Likewise, we have the flip-flop: when neural connections go unused, they weaken or are let go. Thus the phrase, *use it or lose it*.

So, what does this mean? It means that experience shapes the brain by determining which connections to keep and which connections to "prune" out. The brain keeps those that are used—for better or for worse! Let's take a look at that.

For better…

On the "for better" side of use it or lose it, when preschool children build with blocks, for example, they observe relationships between, say "height" and "stability." (The higher you build, the more issues you have with stability.) These observations are stored as patterns of connections between neurons that are based on their observations. They can access this information at a later time when they build with blocks again or when they observe a skyscraper in construction. They will even be able to bring up a picture of the blocks in their mind. It's like an information bank account. Connections in the brain that are used get kept. This is how knowledge is constructed.

When a child is "fully" engaged in some activity (such as coloring, looking at a book, building a train track), she or she is laying down, in the brain, patterns and relationships that are observed or experienced. The patterns are more complex and widespread in the brain when the child is fully engaged – *more* complex than when a child is not engaged for some reason, maybe is distracted by being sick or hungry or sad or bored.

Promoting engagement in learning can be done in many ways. One of these ways is to make the content personally relevant to each child. As a young Head Start teacher in 1969, I was always looking for ways to ease the children's transition from circle time to going down the long hall in this elementary school to use the bathroom and wash up before lunch. I'd done the usual things like "who has on red today?"

One day I tried playing with their names. So, for Karen, I would ask, "Whose name sounds like Baren?" For Timmy it was "whose name sounds like Simmy?" This group of 4 year olds thought this was SO funny!! In fact, they really loved this game and wanted to play it every day. Eventually, they could come up with the "sounds like" names themselves!

Now, in 1969, Head Start had been around long enough (4 years) that legislators began to ask if this program was worth the cost to the Federal Government and the nation's taxpayers. Enter "assessment" and "accountability"!

We were being asked to measure changes that could lead to later school success. One of the tests given at the end of the year to the children in this Head Start center was a Kindergarten Readiness test. When the results came back to the program, the Director came down to my room and asked me what the heck I'd been doing, as the children in my classroom had scored off the charts (at second grade level) in "initial sound discrimination"! I thought for a minute and then realized, of course, that it was the "whose name sounds like" game.

The children loved that game! It was about them…*their* names, and it was so funny to them, you know preschool style humor! Whenever we did this transition activity, they all were intensely focused on the game, trying to be able to figure out whose name it was! When they did, they would yell it out, laughing all the while. It was a pretty noisy transition! But, they really learned initial sound discrimination, which is a critical skill for decoding a word phonetically, and reading – literacy – is part of the culture we pass on to each succeeding generation.

Since what we "do" gets wired into the circuits of our brains, even the very "act of being engaged" lays down a pattern, so the child can become engaged again with greater ease. Becoming engaged comes to be automatic! It is up to teacher-caregivers of young children to ensure that the children are safe in the setting – both physically and psychologically. Every teacher-caregiver must actively create a warm and supportive relationship with each child in her or his care. In the context of the attachment that forms and the safety that brings, the child can become engaged again and again.

For worse…

Now, let's look at an example from the "for worse" side of the *Use It or Lose It* principle. If a child, for example, is the victim of bias (be it ethnic or racial bias, gender bias, ability bias, or so on), this child will have to spend a lot of time and energy trying to cope with the people who are expressing that bias. Some children who Frightened Girl by are victimized may become hyper-vigilant to other people's reactions or behavior for the sake of self-protection. Because this is what the child is "doing," this exaggerated *stress* response can lay down patterns in the brain, so that *it* becomes automatic. Since hyper-vigilance usually comes with elevated and sometimes chronic anxiety, it takes a toll on both the child's learning and health.

What we "do" will come to be wired into the neural circuits of the brain, for better or for worse. The hours spent playing video games or watching television grab a lot of cortical space and strengthen our ability *and preference* to learn in these ways, at the expense of space that could be used for, say, reading or listening. Learning from a book or a lecture becomes hard. In the world of the cortex, there is a constant competition for "real estate" – for connection. Use it or lose it. This concept goes hand-in-hand with the next.

Concept #3: Repetition forms stronger and more elaborate memories. Simply put, the more we "do" something, the more numerous are the connections between neurons, and the stronger the connections are neurologically. This is especially true if we repeat activities on multiple occasions, on different days, or over time. We get better at it, understand it more, and can apply it. Remember the old saying, "Practice makes perfect?" Well, we may not be aiming for perfection, but practice does yield ability and expertise.

Take concepts of number for example. In one study, researchers found that Early Childhood teachers who "use numbers in their everyday speech may aid their students' math abilities." (Dingfelder, 2006, 10) For example, in getting ready to go outside, a teacher could say, "You two get your coats on, please," instead of saying, "You guys get your coats on, please." Hearing number references throughout the day within the context of the daily activities helps the child build more elaborate concepts of number and number relationships.

Some teachers limit the number of children allowed to play in each of the activity centers, and they put up a sign with the number of children allowed expressed as both a number and as that many stick figures. This brings up the use of number as well as addition and subtraction in a "real" way for children on a daily basis. This prompts them to learn how to count accurately, so they can figure out if they can go into the area.

As children work with the same open-ended materials over and over again, like blocks, paints, and clay, they construct a richer understanding of the uses of the materials, which, in turn, provides scaffolding for doing more with the material. As a child learns more about something, the new knowledge supports the child to *think* about it at higher and higher cognitive levels and to *apply* what they learn to other situations. This is an example of how brain science findings give support to the theoretical concepts of Lev Vygotsky.

I remember the first time I had real artist's clay to use with preschoolers! I became committed to having it out as often as I would have put out playdough. For quite a while, the children simply explored the new qualities – which are not at all like play dough. I kept putting it out. Then one day (this was a parent co-op preschool) I had two fathers as assistants, both of whom gravitated to the clay. Within about 20 minutes, there were about 8 children at the clay table which was becoming covered with a sort of jungle/forest with an interesting variety of animals! All the while, they talked about what they were making and why. The children and adults stayed at this activity for over an hour!

The children needed to work with the clay over and over again until they developed a sufficient knowledge of the material, and then they could take it to a much higher level and begin to express what they had in their minds. They got ideas from each other and from the adults which provided scaffolding, in Vygotsky's words, to support more mature thinking as well as more mature behavior. And, emotionally, they had a great time!

Lillian Katz wrote an article a number of years ago about the difference between education and excitement in early childhood classrooms. She admonished us not to fall into the trap of having something *new* every day. Whenever children come across novelty- something new, they have to spend a lot of time (as well as brain space and power) in exploring the new material or activity.

The processes and knowledge required don't have enough time to become routine or automatic, which is the point at which we can use the skills and materials to express our ideas and solve problems. For example, once a child becomes familiar with scissors, paper, and glue – then, the child can create something with those materials. The child may even think about what they want to make at school the next day, if they know what the possibilities are with the materials at hand. Familiarity with materials provides scaffolding for creation and learning.

Function of Frontal Lobes

Elkhonon Goldberg, in his book on the frontal lobes, states that "unlike instinctive behavior, learning, by definition, is change…. At an early stage of every learning process the organism is faced with *novelty* and the end stage of the learning process can be thought of as *routinization* or familiarity.

The transition from novelty to routinization is the universal cycle of our inner world." (2001, 44) In fact, novelty is processed more strongly in the right hemisphere and cognitive routines are processed more strongly in the left hemisphere, though it may be the opposite in left-handers. According to Goldberg, as the neural activation moves its concentration from the right hemisphere to the left, there is "an overall decrease of prefrontal activation."

This means that skills that have become automatic or routine don't take up as much cortical space or energy as do novel experiences. Automatic skills and knowledge can be combined in new ways, which usually takes the child to a more mature way of thinking or behaving. So, having paper, crayons, scissors, glue, tape, etc. available for children every day allows them to advance their thinking and problem solving when using these familiar materials, rather than having to start at the beginning and explore the essential nature of novel or new materials. Repetition forms stronger and more elaborate memories.

Concept #4: Cells that fire together, wire together.

Experiences that occur together in time and space are connected in the brain, literally. "Associations" can be remarkably strong and long lasting. All thoughts have associated emotions connected to them. All experiences have emotions connected to them. If one of our goals is to help children develop a love of learning, we need to make sure that the learning environment is positive, supportive, individualized, and embedded in warm relationships.

In addition, the materials and activities must also be developmentally appropriate. Bruce Perry says that if a child is asked to do something or learn something that is "beyond his grasp, the pleasure of learning diminishes. If a child fails repeatedly, he will be less willing to take on new challenges-even if these new challenges are well within his grasp." (Perry 2000)

Guidance of children must have learning as the goal. Teacher-caregivers should employ positive guidance techniques and explain the "why" of a rule or guideline. Cells that fire together, wire together. If consequences are imposed in response to an unacceptable behavior, they must be logically related to the misbehavior and consistently applied, if we want the child to remember them. For example, repeatedly crashing a bike into the wall leads to loss of bike use for the day. Children learn rules and guidelines through repetition. Thus, predictable daily schedules allow children to respond to transitions between activities with more self-regulation and less chaos.

Concept #5: Plasticity of the brain's connections and functions is *where* adaptation occurs.

The brain changes its structure minute by minute, in a multitude of ways, adapting itself to a changing environment. Right now, your own brain has changed from what it was when you walked in here.

The changes in the brain that occur during the first 20 years of life are creating basic architecture as well as encoding memories and constructing knowledge based on our experiences. During all of adulthood, the brain continues to construct itself and solves problems- big and small. As we solve problems and attempt to achieve goals, we learn from the results and use this information the next time. Each time we re-visit a problem to solve or a goal to achieve, we re-construct our knowledge of it, we adapt. Describing the brain as "dynamic" is an understatement. It modifies itself every minute of every day in multiple ways at once.

What do scientists mean by "plastic" when they talk about the brain? Take a second to think about all the forms that plastic can take: grocery bags, children's toys, telephones, medical equipment, shrink wrap, and sippy cups, to name but a few! The thing about plastic is that it can take many forms, depending on what we do to it. If we process plastic one way it is very hard with a rigid shape, process it another way and it is soft and formless. Well, the brain, too, is plastic. It changes its "shape" (so to speak) depending on the experiences it has, just like plastic materials.

So this concept that the brain is plastic, tells us that the experiences that we have determine the *structure* of the brain (in terms of connections between neurons), which in turn will impact all later thoughts, feelings, growth, and behaviors throughout the whole life. So, in this sense too, we are what we do, especially in the early years.

Plasticity in the brain also means that when there is damage to an area of the brain, the brain can reorganize, particularly in childhood. Since the brain is developing very rapidly in the first five years, early intervention services for children with disabilities can have a huge impact on changing that plastic brain in a way that will help the child overcome their disability or adapt to it more successfully. A basic concept of early intervention is "the sooner the better" and that is supported by neuroscience. The developments in the brain that happen early in life are producing structures upon which all other development and function will depend. Early brain development provides the base for all later development.

During the period from birth to young adulthood, the brain is *especially* plastic because it is still creating its basic structure; and, the younger the child, the more plastic the brain is. So, the activities that the developing person does the most, spends the most time at (what we call "sustained activities") will have a big impact on the brain, especially if they start to do these activities in the early preschool years.

For example, children who learn to play a musical instrument fairly early in childhood (typically between 3 and 8 years of age), will create more connections between neurons (larger brain maps), in the places in the brain that are involved in playing that instrument. These can be brain maps for behaviors such as movement and sound perception. Studies of young children who learn to play the violin starting at age 3-4 show larger brain areas devoted to the fingers of the left hand that push down the strings to make the correct note. The impact on the brain of activities that we do is not limited to things like learning to play the violin. Norman Doidge gives the following examples:

> “Brain scans of London taxi drivers show that the more years a cabbie spends navigating London streets, the larger the volume of his hippocampus, that part of the brain that stores spatial representations. Even leisure activities change our brain; [people who meditate and teach meditation] have a thicker insula, a part of the cortex activated by paying close attention.” (2007, 290)

In spite of the impressive flexibility of the brain, plasticity has its limits. We can see this in people who have suffered a stroke. In spite of extensive physical or speech therapy, they may <u>not</u> be able to recover all of their prior abilities. Additionally, neuroscientists have found that brain plasticity declines with age.

Exposure to television

According to Norman Doidge, “Exposure to television between the ages of one and three correlates with problems paying attention and controlling impulses later in childhood.” (2007, 307) This is more of an issue with younger children. With toddlers, as the number of hours they watch television increases, so do “…their chances of developing serious attentional difficulties at age seven….” In fact, in this study, for every hour of T.V. watched by a toddler, their chances for developing a problem with attention increased by ten percent. (Doidge 2007, 307)

<u>How</u> we get our information (by reading, watching, or listening) determines how our brain processes it. One study “showed that different brain areas are involved in hearing speech and reading it, and different comprehension centers [are involved] in hearing words and reading them.” (Doidge 2007, 308) Different modes of learning leave different sets of memories. “Each medium leads to a change in the balance of our individual senses, increasing some at the expense of others." (Doidge 2007, 308)

Concept #6: The frontal lobes of the brain take the longest to develop, and require a lot of practice to mature.

The frontal lobes are the forward most part of the brain and are especially large in humans. The frontal lobes, occipital lobes, temporal lobes and parietal lobes make up the majority of the brain’s cortex. The cortex is the outer layer in the brain that has deep folds and looks like a cauliflower. The cortex is divided into two hemispheres, a right hemisphere and a left hemisphere. The frontal lobes are the "thinking" part of the brain that allows us to move, think, and talk, among many other things. The frontal lobes of the cortex are of particular interest to those of us in child development and early childhood education.

Elkhonon Goldberg, in his book on the frontal lobes of the brain, introduced this area of the brain in the following way.
He said:

> "Frontal lobes perform the most advanced and complex functions in all of the brain, the so-called executive functions. They are linked to intentionality, purposefulness, and complex decision making. They reach significant development only in humans; arguably, they make us human." (2001, 2)

The frontal lobes of the cortex include areas that are responsible for the initiation of motor movement as well as these higher order "executive" functions. Bruce Wexler states that the "late maturing frontal lobe regions play critical roles in language function in general and word generation in particular." (2006, 105)

In fact, it appears, but is not conclusive, that the "development of the frontal lobe functions is dependent upon sensory stimulation." (Wexler 2006, 63) These "executive" frontal lobe functions also include: voluntary attention (we spend a lot of time teaching children what to pay attention to), memory, organization, planning, and strategy selection. Self-awareness and awareness of others are some of the social functions of the frontal lobes.

Since the frontal lobes take so long to mature (to beyond puberty), "…it is not surprising that adults must provide these functions [these executive functions] if they are to be present in the behavior of infants and children…. While the child's frontal lobes are developing, the parents' brains provide frontal lobe functions for the child." (Wexler 2006, 109) For children in full and part day programs, the teaching-caregiving staff members provide the frontal lobe functions for the children.

For example, if a child wants to play at riding the bus, or public transit, she may not know how to get that to happen. The adult (be they parent or teacher-caregiver) can guide the child by asking some questions which will aid in planning. The questions will direct the child's attention to: what materials are needed and how to get them, as well as who is on the bus and what they each do. The adult can ask the child:

- What is the first thing that happens when you get on the bus?
- What does the bus look like on the inside?
- How does the driver know you want to get off?
- Can animals ride the bus? If so, what kind of animals?

Prefrontal cortex

The forward-most area of the frontal lobes is referred to as the pre-frontal cortex. The pre-frontal cortex is located right behind the forehead and is "directly interconnected" (through long axons) with every other area of the brain, with all functional units. It is "singularly suited for coordinating and integrating the work of all the other brain structures...." It brings vision, hearing, language, emotion, meaning, etc. all together. It takes all the parts and coordinates them into a coherent idea. The pre-frontal cortex is the "conductor of the orchestra" and, as such, contains a map of the whole cortex. (Goldberg 2001, 35-6) Damage to the pre-frontal cortex due to head trauma can profoundly disrupt these "conductor" functions, and, thus, "thinking".

Self-regulation

Self-regulation is a frontal lobe function and "one particular aspect of self-regulation is predictive of all academic outcomes" especially early math ability. (Society for Research in Child Development 2007) It is termed the inhibitory control aspect of brain function, and it is used in planning, problem solving, and goal-directed activity. It helps us stay focused on the task at hand and to inhibit being distracted by outside influences or other internal thoughts or urges. Self-regulation must be learned by doing, over and over again, and in many different situations throughout development. Remember that repetition strengthens existing connections and creates new ones.

Self-regulation involves the pre-frontal cortex, as this area "plays the central role in forming goals and objectives and then in devising plans of action required to attain these goals. The pre-frontal cortex selects the cognitive skills required to implement the plans ("What do I know that applies to this?"), coordinates these skills, and applies them in a correct order. Finally, the pre-frontal cortex is responsible for evaluating our actions as success or failure relative to our intentions." (Goldberg 2001, 24) The Tools of the Mind curriculum, by Elena Bodrova and Debra Leong and which is based in the work of Vygotsky, helps teachers support goal directed behavior in children by "arming" them with mental strategies or, what they call, tools of the mind. (Bodrova and Leong 2007, 4) This is a book I highly recommend to teacher-caregivers of young children.

Concept #7: Mirror neuron networks exist. Among other things, they allow us to "feel" other's emotions and "know" their intentions.

Mirror neurons. These special cells in the brain, that were discovered by Giacomo Rizzolatti and colleagues in an Italian lab in 1991, promise to provide us with an awareness of what it means to be human that is unprecedented in the history of psychology. V.S. Ramachandran, a noted neuroscientist, stated in 2001 that,

> "Without a doubt it is one of the most important discoveries ever made about the brain. Mirror neurons will do for psychology what DNA did for biology: They will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious and inaccessible to experiments." (Blakeslee and Blakeslee 2008, 166)

To understand mirror neurons, we need to step back a bit and look first at the concept of body maps in the brain, as described so well by Sandra Blakeslee (a well known science writer) and Matthew Blakeslee, also a science writer and her son, in their book The Body Has a Mind of its Own.

Body Maps in the Brain

New information about the brain indicates that our brain constructs "maps". The Blakeslees point out that the brain has "a complete map of your body's surface, with patches devoted to each finger, hand, cheek, lip, eyebrow, shoulder, hip, knee, and all the rest." (2008, 7) This we have known for quite a while. What is new to Western Psychology is that you have maps for aspects of the world *outside* of your body. There is a "bubble of space around a person's body that his brain includes as part of him in its map of his body." (2008, 214) It extends outward to just beyond your fingertips when you stretch out your arms. Your brain contains a map of this space. Sometimes this space may include your good friend. And, if you use a tool, say a rake or a pencil, this map expands to include that tool as well!

There are touch maps, motor maps, and visceral maps (of your internal organs). In fact, according to the Blakeslees, "Research now shows that your brain is teeming with body maps – maps of your body's surface, its musculature, its intentions, its potential for action, even a map that automatically tracks and emulates [or copies] the actions and intentions of other people around you." (2008, 11) Here I ask you to recall one of the earlier concepts, that of plasticity. It applies to body maps in that they are "profoundly plastic" and can reorganize and change their configurations and what they include based on experiences, damage to the brain, or practice. Learning to cut with scissors involves creating or modifying motor maps! The more children cut with scissors, and the more different materials they cut with scissors, the more complex their maps will be.

According to the Blakeslees, we create these maps in early development and as *we* grow and mature, so do these body-centered maps. In adulthood, they continue to change, but not as fast as they do in childhood. The body maps we create in childhood will be with us for the rest of our lives.

Active Learning

This information alone should give us pause in thinking about the critical importance of "active" learning, play based curricula for early childhood education. If one of the "brain tasks" of the early years is to create these body maps, then it is of utmost importance that children are moving all day in hands on, sensory based activities, hopefully with one or more other children and adults. This is not a new concept! Neuroscience is simply reinforcing and supporting some of the most basic principles of child development and early learning. There is now a known neurological basis for why this hands-on, active approach has worked so well for child learning and socialization.

Now let's look more specifically to mirror neurons. Mirror neurons, according to the Blakeslees "comprise a previously unrecognized element of certain body maps." (2008, 164) They are a "special set of cells within certain high-level body maps that represent actions performed both by oneself and by others; hence, they are key to many higher mental functions, including imitation, empathy, and the ability to read one another's intentions." (2008, 213) The primary role of human mirror neurons is to understand the meaning of the actions of others. (Rizzolatti and Sinigaglia 2008, 124)

Mirror neurons are found in multiple areas of the cortex of the brain. Body maps with mirror neurons are in your Premotor Cortex and these are the ones that are active when you are either doing or perceiving an action (with action being defined as intentional and purposeful behaviors).

There is another body map with mirror neurons in the Superior Temporal Sulcus which tracks body movements happening outside of oneself. It tracks movements such as walking and arm swinging, which would be a survival skill ("Is that a predator in the bushes?"). This body map, one of the main inputs to your mirror neuron circuits, is a part of the visual system that is "exquisitely tuned to biological motion…" –a sort of "life detector". (Blakeslee and Blakeslee 2008, 165)

Sandra Blakeslee and Matthew Blakeslee state that mirror neuron networks or circuits can be thought of as "…body maps that run simulations of what other people's body maps are up to….

They allow you to grasp the minds of others, not through conceptual reasoning, but by modeling their actions, intentions, and emotions in the matrix of your own…" integrated network of body maps. (2008, 166) When someone sweeps with a broom, you automatically simulate or copy the sweeping action in your own brain. The actions that cause the strongest mirror neuron responses are those actions we know best. Thus, early childhood programs help prepare children for elementary school by exposing them to "teacher" behaviors and "school" behaviors. As the children get familiar with these behaviors, they will be easier to understand in first grade. Priming mirror neurons for "school" helps level the playing field for all children.

Mirror neurons allow a child to understand the meaning of other people's actions by "processing them directly within the child's own body maps." (Blakeslee and Blakeslee 2008, 171) This also applies to emotions that we see other people expressing.

Thus, the mirror neuron networks let us "read others' minds, so to speak. The Blakeslees quote Giacomo Rizzolatti saying that "We are exquisitely social creatures…. Our survival depends on understanding the actions, intentions, and emotions of others. We simulate these automatically, without logic, thinking, analyzing." (2008, 167)

Mirror neurons provide internal simulation of what we are observing in others, thus activating the very same cells in our brains that we use to *do* the behavior. Noticing the difference in what it "feels" like to *actually* do something and how it "feels" to watch *someone else* do the same thing is how the infant begins to develop a sense of self in contrast to "other" people.

Developmental stages of mirror neurons

Babies are born with a motor mirror neuron system already in place that allows imitation, within moments of their birth. By age two, children are primarily learning through imitation, "…which lets them absorb far more knowledge and skill than could ever possibly be explained to them verbally." (Blakeslee and Blakeslee, 2008, 172) Their mirror neurons allow them to learn though simply seeing, hearing, and touching. This is more evidence in support of a hands on, play based curriculum, <u>and</u> the use of American Sign Language with babies and toddlers.

In fact, young children's brains are very good at picking up behaviors from others via imitation. (What preschool teacher doesn't know that!?) But, they also are able to "pick up on the *goal* of other people's behavior." (Iacoboni, 63)

Marco Iacoboni (2008, 69) thinks that "one of the primary goals of imitation may actually be the facilitation of an embodied *intimacy* between the self and others during social relations."

Mirror neuron networks allow us to really know other people. We know people's intentions as well as the contents of their behavior. We can detect "fakes". We can feel another's pain.

Emotions are contagious

We actually feel what the other person is feeling. This is why your stomach jumps when you see a young child trip and fall! We literally "catch" what the other person is feeling. Thus, the quality of our relationships with other people has an impact on how we feel and function. According to Daniel Goleman (2006, 5), "…nourishing relationships have a beneficial impact on our health, while toxic ones can act like slow poison in our bodies." Toxic relationships, especially in a workplace cannot be ignored.

Implicit Bias

Mirror neurons "operate largely outside consciousness," so we are not aware that they are working. (Blakeslee and Blakeslee 2008, 176) This means that if a child is exposed to adults who hold a bias of any variety (racial/ethnic bias, gender bias, etc.), the child will absorb the attitudes and assumptions without being aware of it. These types of unconscious attitudes are what psychologists call "implicit bias". Implicit bias DOES influence our behavior, and children do "read" it on us and mirror it, feel it, and incorporate it into their knowledge about the world. Racism, sexism, able-ism, homophobia – all the biases are contagious.

On the other hand, tolerance, acceptance, active anti-bias-ism are also contagious. If we work to find out the stereotypes we hold of certain characteristics of people, and then work to "learn" the opposite attitude, children will see <u>this</u>. They will copy <u>this</u>. They will internalize <u>this</u>.

Mirror neurons give us the neuroscience explanation for Albert Bandura's social learning theory and the impact of role models on children's behavior and thoughts. Children learn more from us than we ever realize! Thus, it is critical that teachers of young children actively work on discovering and actively reducing biases that they hold about other people. To avoid this work is unethical, because the very first principle of our Code of Ethics says "Do no harm." Bias harms both children and adults. To ignore this critical, personal work is harmful. I feel very strongly about this. We cannot put it off to later.

Important work to be done

I'm going to give you some homework! I invite you all to go to the following web site, Project Implicit, (https://implicit.harvard.edu/implicit/) and take some of the Implicit Bias tests that are there. You do them right on your personal computer. You will receive information and an interpretation of your results. This can give you somewhere to start. Awareness is critical, but you cannot stop there. Therefore, I'm also going to teach you a technique for countering biased attitudes that you discover you have.

In an article entitled "Buried Prejudice", Siri Carpenter sites the following unpublished study that was done by B. Keith Payne and Brandon D. Stewart. This study addressed the question of how you can gain control over automatic processes that underlie implicit biases. Payne and Stewart used a commonly held implicit bias, which is a fear of African Americans, especially African American men.
The authors:

> "found that those [people in their study] who simply resolved to think of the word *safe* whenever they saw a black face showed dramatic reductions in implicit racial bias. You don't necessarily have to beat people over the head with it, Payne observes. You can just have this little plan in your pocket [think 'safe'] that you can pull out when you need it. Once you've gone to the work of making that specific plan, it becomes automatic." (39)

The bias got into our heads through associations, so it makes sense that we can disrupt them through purposely making different associations – ones that contradict the stereotypes. A friend of mine, who has mobility limitations and uses a motorized wheelchair, told me that many people hold a bias that people in wheelchairs are not smart. For this bias, using Payne and Stewart's approach, we could fight it by thinking "intelligent" whenever we see a person who uses a wheelchair.

Concept #8: The brain is a "social" brain.

"We are wired to connect," says Daniel Goleman. (2006, 4) Our brains are set up to make relationships with other people. We are learning that the interaction between parent and baby is critical for the setting up <u>and</u> activation of the mirror neuron networks, which are necessary for effective social interaction and the development of empathy.

Marco Iacoboni points out that imitation and mirror neurons allow us to develop a sense of intimacy between ourselves and others, which is "a building block of social cognition…. The study of early human development also shows how imitation is powerfully linked to the development of important social skills – for instance, the understanding that other people have their own thoughts, beliefs, and desires." (Iacoboni 2008, 70) In cognitive psychology, this is referred to as a child's Theory of Mind or metacognition.

Our brains require social contact from the moment of birth. For example, parents aid their baby in learning how to return to a state of equilibrium after getting upset. They do this by quieting the baby through such techniques as rocking, cooing, touching, talking or singing in a soothing voice. The parents figure out what works and then keep using this approach. The baby comes to expect this approach and "…is quieted more quickly when it is held and soothed by its mother than when it is held and soothed by another woman, even if the second woman has had as much or more experience caring for infants as the infant's own mother." (Wexler 2006, 99-100) The baby's brain develops connections around this quieting, and these connections will eventually support the baby's ability to return to that state on their own when they get upset.

This knowledge reminds us of the importance of continuity of caregiving for infants and toddlers. They need consistent (meaning "the same") caregivers throughout the day and over time. This is one of the significant strengths that the family child care model can offer, as well as continuous care models in centers – where the teacher starts with the youngest age group and moves with them as they grow. High staff turnover often found in full day programs subjects these youngest of children to a very stressful and confusing environment, not at all conducive for attachment, predictability, or learning. Children thrive in long-term, supportive, reciprocal relationships with people who form a bond with them. This is what the brain is expecting, which leads to the 9th and final concept.

Concept #9: We are designed to make culture. Culture is the way humans adapt to the changing environment.

The baby's brain adapts itself to match the brains of the people who care for and interact with the baby. The baby attunes herself to her caregivers so she begins to see the world as they do. She pays attention to what they pay attention to, moves her body in rhythm to their speech patterns, and makes maps of these. Babies learn the gestures of their parents and caregivers as well as their meanings, and babies come to expect to see them.

According to V.S. Ramachandran, discovering and studying mirror neuron networks gives us an alternative explanation for brain development in humans. He says, "Your brain is unique not because it has evolved highly specialized modules, but because it is parasitic [or symbiotic] with culture…. Mirror neurons absorb culture the way a sponge sucks up water. You learn much more easily how to shoot an arrow or skin a bear by watching your mom and dad [do it] than by listening to them describe it." (Blakeslee and Blakeslee 2008, 171)

"Mirror neurons set the stage for the horizontal transmission of culture," (Blakeslee and Blakeslee 2008, 171) from parent to child, from person to person. Reading, and math, and language, and customs are passed on this way. Our brains adapt themselves to the particular details of the unique culture that envelops us.

Culture is not the icing on the cake, culture is the cake! We make culture, and then the culture in turn changes our brains. Our changed brains then modify the culture further. It's what we "do".

Conclusion:
In conclusion, I would like to summarize and emphasize a couple of the most important concepts and their applications.

1. Each child has a unique brain which is ready to adapt and learn. For the youngest children, we must try as hard as we can to adapt the program, the people, and the curriculum, to the child, and not visa versa. As children enter the 3-5 years, we can begin to introduce them to different environments, routines, and guidelines. We must support the child learning how to adapt to the group, to the school culture. As we do this, we must remember that with every thought and every behavior, there is an emotion attached or associated with it. Quality of relationships and quality of caregiving is critical.

2. Be ever aware of your "frontal lobe" role for children. Teach children strategies for planning, setting goals, and achieving them. Remember that this responsibility for supporting "frontal lobe" executive functions continues into early adulthood.

3. And finally, keep in mind that people of ALL ages can "read your mind" with their mirror neurons. All your feelings and biases and preferences are "public" – they cannot be hidden. And, as such, these biases and preferences can impact others. The only solution is to recognize what those biases and preferences are, and work on changing the ones that are negative, are stereotypes, and are detrimental to other people, young and old.

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