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Support Healthy Brain Development: Implications for Attention Deficit/Hyperactivity Disorder^{1, 2}

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Abstract: Neglecting and disregarding our evolutionary background during infant, toddler and childhood stages of development may contribute to the increase in diagnosis and treatment of attention deficit/hyperactivity disorder (ADD/ADHD). To optimize healthy brain development, the following factors need to be supported: 1) Breast feed children at least for one year and concurrently introduce new foods slowly after 6 or 8 months to reduce the risk of developing food allergies; 2) Respect the importance of face-to-face contact to provide safety, develop empathy and nurture social connection; 3) Provide routine and ongoing parental attention and support circadian rhythms; 4) Integrate vision with touch and movement by encouraging motor development such as crawling, playing in nature, and physical movement that occurs while playing games instead sitting and being entertained by smartphones, computers, tablets or TV screens; and 5) Provide face-to-face reassurance when overwhelmed with rapidly changing visual and auditory stimuli. Health implications of new digital devices are discussed.

Keywords: attention deficit/hyperactivity disorder (ADD/ADHD), digital devices, breast feeding, motor development, neurofeedback

In class, he fidgets, every auditory and visual stimulus distracts him-- he gets up, talks to other students and disrupts the class. Nothing seems to hold his attention, he looks at the page and moments later turns around and disturbs the boy behind him. At home, he grabs his food and leaves the table. He is continuously distracted. The only thing that seems to capture his attention is his computer games.

Health is optimized when we live in harmony with our biological and evolutionary background. These behaviors allowed survival for thousands of generations. Disorders often occur when we neglect our evolutionary background during infant, toddler and childhood stages of development. Diabetes, obesity, allergies, asthma, attention deficit disorder/attention deficit and hyperactivity disorder (ADD/ADHD) and other illnesses are more common in our modern life style.

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From the moment of birth, parents realize that each child is different- some are quiet and others react to every sound and movement. Yet, how the infant develops depends upon the synergistic interaction between the biology (nature) and environment (nurture). ADD/ADHD disorder is only a disorder if the behavior is too dysfunctional in the cultural setting or if the learning style is not supported by the culture. Drs. Lynda and Michael Thompson, directors of the ADD Centre & Biofeedback Institute of Toronto observed that in running a boys' camp--ADHD boys are often sent off to camp--that ADHD kids were the best on really difficult canoe trips. They were far faster learners of difficult mathematic concepts concerning the relationship of sails and wind if they were taught in the right conditions (wild approaching hurricane winds etc.). They were terrible if you insisted they sit on a dock and just listen (Thompson & Thompson, 2014).

ADD/ADHD has become an epidemic in the last 30 years. Now one in seven boys by the time they reach the age of 18 have received this diagnosis according to the Centers for Disease Control and Prevention, as shown in Figure 1.

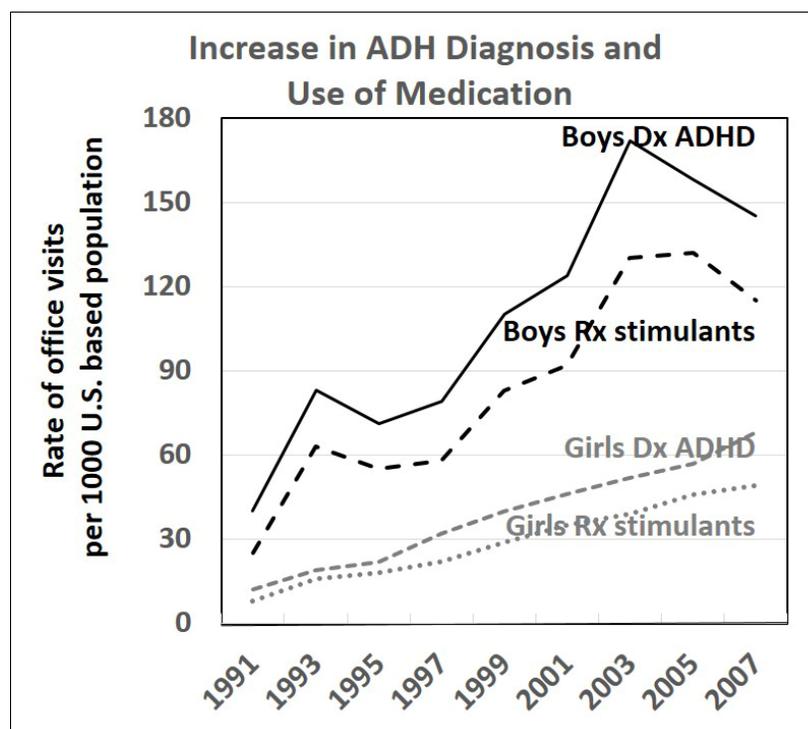


Figure 1. Rate of office-based visits per 1000 US population aged 5 through 18 with diagnosis (Dx) of ADHD and rate of use of medication (Rx) for boys and girls. Redrawn from: Sclar, D. A., Robison, L. M., Bowen, K. A., Schmidt, J. M., Castillo, L. V., & Oganov, A. M. (2012). Attention-Deficit/Hyperactivity Disorder among Children and Adolescents in the United States Trend in Diagnosis and Use of Pharmacotherapy by Gender. *Clinical pediatrics*, 51(6), 584-589.

The increase in ADD/ ADHD diagnoses or diabetes, obesity and allergies cannot be explained by genetics alone. It may depend upon the interaction of genetics and the environment. It

may develop into a disorder as a result of disrespecting and not understanding our evolutionary background during our development. Diabetes and obesity has increased because of a decrease in mobility and an increase in sugar intake from about 10 lbs in the 19th century to 150 lbs per year today (O'Callaghan, 2014).³ Similarly, allergies previously were very rare; however, during the last 20 years they have tripled (Branum & Lukacs, 2009). This spring I was shocked when I asked my students at San Francisco State University how many had allergies. More than 25% of the students said, "Yes". When these illnesses occur(s) we attempt remedy them with medications. The medications for ADD/ADHD (e.g., Adderall, Concerta and Ritalin) provide an 8 billion dollar revenue stream for pharmaceutical companies. Yet, there is little or no evidence of long term benefits (Molina et al, 2008; Schwarz, 2013). Self-mastery approaches such as Neurofeedback have demonstrated long term benefits in improving reading, writing, and mathematical scores as well as decreasing impulsive behavior (Monastra et al, 2002; Arns et al, 2009; Gevensleben et al, 2009; Steiner et al, 2014). Neurofeedback training teaches children how to control their brain function. It is similar to learning a new language, mastering a musical instrument, or becoming proficient in a sport. It takes time and practice to retrain and rewire the brain. **Medications often mask the symptoms.**

We need to recognize that many of the patterns associated with ADD/ADHD have a genetic component. Rapid orienting to external stimuli is very useful for a hunter's survival (Thompson & Thompson, 2014). The hunter with mentorship learns while doing. The learning process is part of body movement, action and changing environmental cues. Presently, we tend to support only a single learning strategy: sitting in chair while observing, thinking, and performing. Being aware of one's learning style and optimizing the environment for that style may facilitate achieving success. Numerous successful people have an ADD/ADHD diagnosis; however, they eventually figured out how use their learning style to their advantage. If the behavior is too dysfunctional then achievement and success is compromised.

Our modern lifestyle has compromised the healthy development of the brain and behavior. Public health education needs to focus on prevention and support the concept that health is promoted when infants during their early developmental stages live in harmony with their evolutionary background. This means optimizing those factors that during the course of evolution promoted increased survival, reproductive fitness and promoted healthy brains.

1) Breast feed children at least for one year and concurrently introduce new foods slowly after 6 or 8 months to reduce the risk of developing food allergies.

³ New evidence suggests that antibiotics use in early childhood changes the bacteria in the babies' guts and makes them more prone to obesity. The same phenomena which has been observed and purposely used to increase animal growth. Kennedy, P. (2014). The fat drug. *New York Times, Sunday Review*, March 8, 2014. <http://www.nytimes.com/2014/03/09/opinion/sunday/the-fat-drug.html>

2) Respect the importance of face-to-face contact to provide safety, develop empathy and nurture social connection (Porges, 2011).

3) Provide routine and ongoing parental attention. As Edward Melhuish of Birkbeck, University of London states, “children under five who don’t receive consistent affection and responsive communication from care-givers may have impaired social and emotional development. Crucially, this affect their language skills, which Melhuish says is a major reason why children from disadvantaged families generally do poorly at school” (Bond, 2014; Melhuish et al, 2008).⁴

4) Encourage motor development such as crawling, playing in nature, and physical movement that occurs while playing games support brain development instead sitting and being entertained by smartphones, computers, tablets or TV screens. Physical movement during play-- without being distracted by the overwhelming rapid changing stimuli shown on LED and TV screens--is necessary for brain development.

Provide support for healthy brain development.

We need to create an environment that promotes brain development and nurtures healthy children or we can continue to disrespect our evolutionary background and pay the long term cost of treating ADHD and other disorders. Although there are many other risk factors, evidence suggest that the following enhances brain development.

Breast feed an infant for at least for one year. Breast milk contain immune factors and appropriate fatty acids that are necessary for brain development (Oddy, 2001; Labbok et al, 2004; Verhasselt et al, 2008; Makrides et al, 1994). Simply put, formula fed babies are malnourished with respect to necessary fatty acids and immune factors that are necessary for brain development. Using formula is like building a large building with substandard materials. Breast fed babies have slightly higher IQ, less obesity, less anxiety, lower rates of atopic eczema and celiac disease and less hyperactivity than formula fed babies when they get older (Horwood, 2001; Belfort et al, 2013; Harder et al, 2005; Julvez et al, 2007; Odijk et al, 2003). When foods are slowly introduced while the baby continues to breast feed there is a significant lower allergy rate such as celiac disease than if breast feeding is abruptly discontinued (Ascher et al, 1991; Cavell et al, 1992’ Carlsson et al, 2006; Kull et al, 2002). More importantly, breast feeding supports the critical social development of face-to-face bonding that is necessary for developing empathy and self-directed attention (Porges, 2009).

Although many mothers would like to breast feed and take care of their babies, they are thwarted by the economic necessity to return to work and/or lack of social and community support to breast feed. In the process of industry and government saving money by not

⁴ A superb summary that a good start in life has far-reaching benefits for health and social functioning is summarized in the publication, *Life Gets Under Your Skin*, <http://www.ucl.ac.uk/icls/publications/booklets/lguys.pdf>

supporting mothers, we all end up paying much higher medical and social costs to treat the illnesses as these babies become adults.

Reestablish circadian (daily) rhythms. Until the 19th century our biological and activity rhythms were controlled by natural light. It is hard to imagine not having light at night to read. When the sun went down, we went to sleep. Now, bright lights everywhere--from the moment at birth in delivery room to the ongoing glow of night lights, monitors, tablets and the street lights, or flashes of car headlights leaking through the windows. Light not only illuminates, it affects our physiology by regulating our biological rhythms by blocking melatonin production which interferes with sleep (Brzezinski, 1997). A child that stays awake after their normal bedtime often loses control and, instead of becoming sleepy, tends to become hyperactive. By disrupting the biological rhythms with light, we are contributing to sleep disturbance which is associated with ADHD. Numerous children with ADHD have mild obstructive sleep apnea and when that is resolved their ADHD symptoms decrease significantly (Huang, 2007; Garetz, 2008).

We keep the light on in the room because the child is afraid of the dark. Fear of the dark is a normal evolutionary fear. Throughout human history this was resolved by babies and children sleeping together with their mothers, family members and other siblings. We have forgotten that by placing babies in a separate room away from the reassuring skin contact, we have created a situation whereby the child can not feel safe. We then alleviate the fear of darkness with light that interrupts sleep and reduces memory consolidation. In some cases, we can reduce this risk factor by letting the child sleep with their parents or siblings or in the same room as thousands of human generations did—sleeping together.

Support touch and movement with vision and sound to develop the brain

During the first years of life, the baby/toddler integrates the visual and auditory world with touch and movement. Motor development is the underpinning of brain development (Wolpert, 2011)⁵. Early seminal studies by Professors Held and Hein at Brandeis University in 1963 showed that seeing and making sense of the world occurred if kittens tactilely interacted with the visual world. In an ingenious study, they paired kittens so that one could walk on a carousel and the other kitten would have the same visual experience except they were carried and did not walk. The kitten who walked developed normal depth perception while the kittens who were carried became behaviorally blind (Held & Hein, 1963; Noë, 2004). The interaction between seeing, touching and movement is necessary for development.

The more hours children watch TV, the higher is the incidence of ADD/ADHD (Healey, 2004). Babies and toddlers are now entertained by watching smartphone screens, tablet screens and monitors instead of kinesthetically exploring the world and integrating/connecting visual and auditory stimuli with touch and movement as shown in Figure 2.

⁵ See neuroscientist, Daniel Wolpert's superb Ted video presentation:
http://www.ted.com/talks/daniel_wolpert_the_real_reason_for_brains



<http://images.gameskinny.com/gameskinny/c9689c75994e58a03dbc5e489d346e55.jpg>

Figure 2. Being captured by a digital device. From:

<http://images.gameskinny.com/gameskinny/c9689c75994e58a03dbc5e489d346e55.jpg>

This lack of interconnection is observed in numerous people with learning disabilities. Some have incomplete motor development, e.g., when they skip, they tend to lift the arm and leg on the same side of the body instead of lifting their opposite arm and leg. This incomplete coordination may have been caused by excessive triggering of the defense (flight/fight) reaction to excessive auditory and visual stimuli. By spending the majority of the time fixated and captured by a screen and sound instead of crawling, walking and playing in nature, children are less likely to develop a mature integrated motor pattern. Children with ADD/ADHD who are re-exposed to nature and play in nature show a decrease in ADD/ADHD symptoms (Kuo & Taylor, 2004; Louv, 2008; Faber Taylor & Kuo, 2011).

Provide constancy and reduce novelty.

A cacophony of sounds, I could not make any sense of it. I finally comprehended one word when the action, a polite bow, and words were repeated time and time again. All of a sudden I could recognize and even say “Konnichiwa” – good afternoon in Japanese. My hosts wanted to help me learn some more words; however, they said one Japanese word after another. I could not remember any of them. Only when a few words with appropriate action were repeated time and time again were they stored in my memory.

When reading a bedtime story, the child wants to hear the same story again and again. If part of the story is skipped, the child interrupts and reminds us to read correctly. When the child is stressed, it wants to hear a past story for comfort and safety. Repetition while feeling safe allows memory to create appropriate neural connections. Learning implies making neural connections and during sleep the information of declarative memory is encoded into long term memory (Walker & Stickgold, 2006). If too many new stimuli occur, the next stimulus overrides and erases the previous one. It isn't rocket science! Neural growth depends upon the appropriate level and type of stimuli.

Too few stimuli hinders brain development. Rumanian orphans who were warehoused with limited stimuli have brains with less grey and white matter than children who were brought up in an enriched environment (Mehta et al, 2009). These Romanian children had difficulty keeping focused attention and making social connections (Chugani et al, 2001; Porges &

Furman, 2011). Similar reduced brain development was shown much earlier in studies with rats by anatomy professor Marian Diamond at UC Berkeley. Rats that were raised in sensory deprived environment had 4% less cortical thickness (fewer number and smaller in size of synaptic junctions) than rats raised in an enriched environment (Møllgaard et al, 1971; Diamond et al, 1975; Mohammed et al, 2002).

Too many novel stimuli may also decrease brain development. When rats were raised in a sensory overload environment--too many toys to play with and too many choices to make--the cortical thickness was slightly less than rats who had a normally enriched sensory environment.

The more hours children watch TV, the higher is the incidence of ADD/ADHD. Babies and toddlers are now entertained by watching smartphone screens, tablet screen and monitors instead of kinesthetically exploring the world and integrating/connecting visual and auditory stimuli with touch and movement.⁶ Children need more time crawling, walking and playing in nature to develop an integrated motor pattern. In a study by Taylor and Kuo in 2011 children with ADD/ADHD who are re-exposed to nature and play in nature show a decrease in ADD/ADHD symptoms.

The rapidly changing visual stimuli from these screens evokes the biological reflexes to attend-- there is something new and it could be safe, dangerous or life threatening. The physiological processes and the important implications for health and illness have been elucidated by the polyvagal theory developed by Professor Stephen Porges (Porges, 2011). This reactivity does not train self-control or internally generated attention. Over-stimulation with digital devices has been associated with impaired learning and decreased ability to self-regulate (Rowan, 2014; Christakis, 2004). The flood of novel visual and auditory stimuli trains the brain to react, to react again, and again. The ongoing external novelty captures the child's attention, instead of directing attention from within.

Something similar is observed in college students. Professor Andrew Lepp and colleagues at Kent State University discovered that the more the students use their cell phones and text, especially while studying, the lower is their grade point average and the higher their anxiety (Lepp et al, 2014). In our 2013 survey of university students almost all students reported texting or internet surfing during lectures, dinner, and social gatherings (Lin et al, 2014). Their attention is continuously interrupted instead of staying on focus. Students can learn to reverse this distractive process through neuro- and biofeedback as well as arranging their environment so that there are time periods without any interruptions. Even adults can experience the paralysis of too many choices and stimuli. If you have only one or two choices, you become happier and content. With too many choices, you keep thinking, "May be the other one would have been better".

⁶ See Cris Rowan' blog, 10 Reasons Why Handheld Devices Should Be Banned for Children Under the Age of 12. http://www.huffingtonpost.com/cris-rowan/10-reasons-why-handheld-devices-should-be-banned_b_4899218.html

In the last 50 years we have radically increased the visual and auditory input to a developing baby following the concept of more is better. Babies are now exposed to visual and auditory stimuli which rapidly pass by them without repetition or the ability to kinesthetically interact with them. Until the 19th century babies were carried either against the chest of their mother so that they would face their mother or be in continuous contact in a sling on their back. Babies also faced their mothers in the 19th century baby carriages. Now babies are often carried on the chest or in baby carriages/strollers facing forward- leading the charge into the unknown--instead of receiving face-to-face reassurance from the parent, touching the parent, or hiding behind the parent for safety as shown in Figure 3 and 3b.



Figure 3a. Babies being terrified while facing forward. Source: Source: http://1.bp.blogspot.com/-1Mp59-tg-QI/UZvLWOxGhEI/AAAAAAAAANw/RhuX-K3k_mM/s1600/Baby-Stroller.jpg



Figure 3b. Baby being bored and missing attention. The modern style of neglect—physically present while being emotionally and mentally somewhere else. Source: <http://www.momlogic.com/images/mom-carrying-her-baby-pm-thumb-270x270.jpg>

On the average babies spend more than two hours a day in a baby carriage and there is much less social interaction between the mother/caretaker and the baby when the baby faces forward. In a study of 2722 observations of parent-child pairs by developmental psychologist Dr Suzanne Zeedyk (2008), parents talked twice as much to their baby when it faced them than when the baby was facing forward in the stroller. The impact of stress was measured by the decrease in baby laughing. Babies who faced their mother/caretaker while being pushed laughed 90% more than those who faced forward. As babies become older they do want to face the environment as it is more interesting; however, when the infants feel overwhelmed

or threatened there is an opportunity to automatically reconnect with the caretaker to feel safe.

Finally, we park children in front of smart phones, tablets, Gameboys, and television screens that flood the auditory and visual senses without the ability to integrate it through touch and movement. Although TV and computer games are superb baby sitters, it is not the same as interacting and playing with a baby and toddler to develop the appropriate motor and emotional control. Sitting and watching computers, tablets or TV screens gives rapidly changing stimuli of the screen and overwhelms the person by choices and contributes to increase in physical and mental illness (Mentzoni et al, 2011; Rowan, 2014). Let's create an environment that is in harmony with our evolutionary background--An environment where infants play interactively with objects, explore nature and have face-to-face contact with their caregiver.

Even if the initial conditions during growing up were less than optimum, the brain can change—a process known as neuroplasticity. Thus, nurture inner directed attention by having your child develop skill mastery. Learning these skills can include neurofeedback training, back-to-nature explorations, learning to play a musical instrument, practicing a sport or martial art technique, or participating in yoga and meditation. These and many other practices will change the neural structure: it is never too late to learn, change, and optimize health.

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