Anatomy & Physiology: Current Research

ISSN: 2161-0940

Losardo et al., Anat Physiol 2016, 6:2
DOI: 10.4172/2161-0940.1000209

Mini Review Open Access

Neuroplasticity and Young Children with Autism: A Tutorial

Angela Losardo*, Kimberly C. McCullough, Emily R. Lakey

Department of Communication Sciences and Disorders, Beaver College of Health Sciences, Appalachian State University, North Carolina, USA

***Corresponding author:** Angela Losardo, Department of Communication Sciences and Disorders, Beaver College of Health Sciences, Appalachian State University, 730 Rivers Street – Edwin Duncan Hall Boone, North Carolina 28608-2165, USA, E-mail: losardoas@appstate.edu

Rec date: Jan 31, 2016; **Acc date:** Mar 07, 2016; **Pub date:** Mar 14, 2016

Abstract

Autism spectrum disorder (ASD) is a developmental disability characterized by deficits in social communication and social interaction skills, as well as repetitive patterns of behaviors, interests, and activities. Theories related to neuroplasticity and brain development before 3 years of age lend support the notion of critical periods during which cortical circuits in the brain are refined by experience. Advances in early identification of ASD have led to an increased focus on early interventions targeting critical developmental skills in the first three years of life. The purpose of this tutorial is threefold. First, the principles of neuroplasticity and factors that support neuroplasticity will be addressed. Next, the malleability of the developing brain and the importance of early intervention for young children with ASD will be discussed. And finally, practical suggestions for caregivers and health-care professionals will be outlined including screening for early markers of autism spectrum disorder, encouraging active caregiver engagement in the intervention process, embedding intervention in natural environments, and using an integrated approach to early intervention.

Keywords: Autism spectrum disorder; Neuroplasticity; Developing brain

Introduction

"On one of her first home visits with the Martinez family, Ms. Harkins, a speech-language pathologist, met with Gabriella, an adorable 18-month old child and her mother. Gabriella's mother reported that her pregnancy was normal and that Gabriella was delivered without complications. Gabriella's birth weight was within normal limits at 6 pounds, 12 ounces and her vision and hearing were assessed as normal. During the meeting, Ms. Harkins asked Mrs. Martinez about Gabriella's developmental history. Mrs. Martinez reported that Gabriella met physical milestones at appropriate times (e.g., crawling at 6 months, walking at 1 year of age, etc.). However, Mrs. Martinez expressed concern because Gabriella was not using language and communicating like her other three children had done at her age. She noted that Gabriella was not babbling or making sounds, showing interest in toys or other objects, or using gestures. Rather she seemed not to look directly at her mother's face, did not respond to her name when called, and she used repetitive actions and movements such as flapping her hands while looking at the light in her bedroom."

Gabriella language, communication, and social development are not unlike other young children diagnosed with an Autism Spectrum Disorder (ASD). ASD is a lifelong developmental disability characterized by significant delays in language, communication, and social behaviors. According to the Centres for Disease Control Autism and Developmental Disabilities Monitoring Network (2014), ASD is estimated to affect 1 in 68 persons in the United States. In a recent 17-year follow-up study of 192 children referred early for possible autism, their expressive and receptive language abilities were measured on six occasions between the ages of 2 and 19 years [1,2]. Considerable variation was noted in progress on receptive and expressive language abilities between the ages of 2 and 6 years. The authors noted that while this variation in development may reflect a genetic predisposition to autism, they speculated that it may, in part, be related to whether or not a supportive early language environment is provided.

The purpose of this tutorial is threefold. First, the principles of neuroplasticity and factors that support neuroplasticity will be addressed. Next, the malleability of the developing brain and the importance of early intervention for young children with autism will be discussed. And finally, practical suggestions for caregivers and health-care professionals will be outlined including screening for early markers of autism spectrum disorder, encouraging active caregiver engagement in the intervention process, embedding intervention in natural environments, and using an integrated approach to early intervention.

Neuroplasticity and the Developing Brain

Neuroplasticity is the lifelong ability of the brain to reorganize as a result of experience. Specifically, Kleim and Jones et al. [3] define neuroplasticity as functional reorganization within neural tissue, mediated by changes in neural circuitry. Learning is the by-product of neuroplasticity. Said another way, neuroplasticity is experience dependent, and behavioral training is key to promoting brain reorganization.

The brain needs training to maximize its potential for appropriate functional reorganization. Kleim and Jones [3] acknowledge that a better understanding is needed of when and how much training should be given for optimal response. Then, too, little is understood about how training interacts with the developing brain and self-derived compensatory behaviors. Nonetheless, the fact remains that intervention is needed.

The concept of neuroplasticity implies that the brain essentially re-wires itself and adjusts its own "geography" in terms of cortical representation on the basis of changes in environment. It is now known that engagement in thinking, acting, and learning result in significant changes to the brain's physical structure and function. If we

accept that brain changes alter observable behaviors, and that behaviors in turn can alter the structure of the brain, one basic question is how does that work? There is a burgeoning body of evidence that indicates early intervention can result in significant neural changes that are measurable with brain imaging [4-7]. Table 1 highlights intervention techniques supported by the principles of neuroplasticity.

Principle of Neuroplasticity	Intervention Strategies	Factors that Support Neuroplasticity
Timing	Early intervention is key.	Plasticity is greater in childhood.
Attention	Model "in the moment" feedback to child and caregiver.	For learning to occur, the child must attend to the activity.
Stimulation	Infants and toddlers learn best in familiar contexts with familiar people.	Sufficient stimulation is needed to create the long-term potentiation in synapses that creates durable memory
Specificity	Identify regularly occurring routines.	The type of stimulation affects the outcome of the stimulation (e.g., visual processing practice improves visual processing, but not auditory processing).
Reward	With challenging behaviors, determine the function of the behavior and then teach an alternative and more appropriate social communicative behavior.	Sustain attention and activation of targeted skills, thereby improving learning.
Repetition	Embed intervention into everyday activities and interactions.	Repetition is essential for strengthening knowledge and skills.
Intensity	Recommended 25 hours per week in which the child is actively and productively engaged in meaningful activities.	Sufficient intensity is needed to create change in the brain.
Duration	Utilize a team approach that includes caregivers in all aspects of intervention planning and implementation.	Sufficient duration of stimulation is needed to create change and maintain knowledge and skills.

Table 1: Intervention strategies that support neuroplasticity.

Importance of Early Intervention for Infants and Toddlers with Autism

Autism spectrum disorder (ASD) is a complex disorder characterized by deficits in social communication and social interaction and repetitive patterns of behaviors, interests, and activities [1]. In the not too distant past, clinicians thought little could be done to change the brain functioning of individuals with ASD. Early identification of those affected was not the priority it is today. However, as the number of children with ASD has skyrocketed, interest in early detection and intervention also has skyrocketed. In the human brain, there are multiple systems for learning and information representation that are not equally vulnerable to ASD. Clinicians can now enhance early intervention strategies by capitalizing on the factors of neuroplasticity to produce learning in individuals with ASD.

Behavioral symptoms of ASD develop begin to emerge in the first few years of life when brain development is occurring at a rapid rate. Structural neuroimaging studies in ASD consistently report early brain overgrowth between 2 and 5 years of age. This atypical cortical growth appears to be most evident in the frontal lobes; however, other areas such as the cerebellum and limbic system have been identified [8]. In the frontal lobes, abnormalities are associated with learning and problem solving, executive functions, and social-emotional responses [9]. Additionally, these abnormalities are thought to contribute to an inability to interpret the emotional state of others resulting in difficulties with joint attention, social-emotional behaviors, and social-communicative behaviors [10]. Although not well understood, the cerebellum is thought to play a role in language processing, visuospatial skills, and executive functions. [9].

Two structures within the limbic system, the hippocampus and the amygdala are reported to be altered by ASD. The hippocampus contributes to both memory and the ability to respond in an emotionally appropriate manner to external stimuli [11]. The amygdala is known to contribute to processing emotions such as fear, anger, and pleasure. These abnormalities for the amygdala may contribute to poor social communication skills and increased anxiety during social communication.

Little research has been conducted on the verbal skill development in populations of children with autism below the age of 3 [12]. Theories related to neuroplasticity and brain development before the age of 3 lend support the notion of critical periods during which cortical circuits in the brain are refined by experience [13-15]. One responsibility of clinicians is to provide stimulation that will produce positive structural and chemical changes in the brain to positively alter the clinical manifestation of ASD. Considerable improvements in the communication skills of young children with autism can be attributed to early intervention provided before the age of 4 and the involvement of caregivers and practitioners in the intervention process [16-19].

Practical Suggestions for Caregivers and Health-care Professionals

Advances in early identification of ASD have led to an increased focus on early interventions targeting critical developmental skills in the first three years of life. In this important and dynamic period of development, the brain demonstrates the greatest plasticity and potential to alter the course of development. Research suggests that intervention beginning before age 3 yields greater positive outcomes as compared to intervention starting after 5 years of age [20,21].

Caregivers and health-care professionals play a significant role in shaping the developmental trajectory for infants and toddlers with or at risk for ASD. A growing body of evidence supports the efficacy of caregiver-implemented interventions in promoting the development of social-communication skills [22-26].

Considerations for caregivers and professionals include awareness of and focus on early markers of social-communication development, active caregiver engagement in the intervention process, embedded intervention in natural environments, and an integrated approach to early intervention. In the next section, practical suggestions for caregivers and health-care professionals who work with young children with ASD are provided.

Suggestion 1: Screening for Early Markers of Social Communication Development

Early social communication skills in typically developing children under 12 months of age include shared positive affect, joint attention and gesture use (e.g., pointing, waving bye bye). Toddlers between 12 and 24 months typically use words for a variety of functions and imitate routines and other children. Older toddlers use symbolic play, understand theory of mind (that others' needs can be different than ones' own), and take three-to-four conversational turns. It is within this critical period, before the age of 3, that behavioral characteristics, or "red flags" of ASD can be identified, and early intervention services can have the greatest impact. It is essential that caregivers and health-care professionals are knowledgeable of patterns of typical and atypical development and participate in recommended screening procedures in order to identify children with behavioral characteristics of ASD and begin intervention services as early as possible. The American Academy of Paediatrics recommends screening specific to ASD at 18 and 24 months, with additional screening if a child is high risk (e.g., has a sibling with ASD). Knowledge of both typical development and behavioral characteristics of ASD can assist caregivers and healthcare professionals to identify potential social-communication delays or abnormalities in this critical period of development and neuroconnectivity and potentially improve developmental outcomes.

Suggestion 2: Encourage Active Caregiver Engagement

Once a child has been identified with a delay or atypical pattern of social-communication development, the method of service delivery is an important consideration for intervention. Infants and toddlers learn best in familiar contexts with familiar people. Caregivers have significant influence on how young children experience and interact with their environment and parent-implemented intervention is a well-documented method of effective service delivery for infants and toddlers with ASD [27,28]. Consider the following strategies caregivers and health-care professionals can use to support active caregiver engagement.

Utilize a team approach that includes caregivers in all aspects of intervention planning and implementation. Reflection and problem solving can support the intervention process and provide valuable feedback about what is working and what is not. Questions such as *"How do I know the child making progress?"* can assist caregivers and health-care providers in maintaining an ongoing dialogue and assessment of intervention.

Employ a caregiver coaching approach to intervention. Caregiver coaching is a term used to describe interactions between professionals and caregivers that result in caregivers' increased capacity to support their child's learning and development. An example of a coaching strategy is guided practice with feedback in which the early intervention provider guides the caregiver's interactions with the child 'in the moment' by offering specific suggestions and feedback related to caregiver-child interaction [23-30].

Suggestion 3: Embed Intervention within Context of Natural Environments

The importance of early, intensive intervention for young children with or at risk for ASD is well-documented [11]. However, achieving the recommended 25 hours per week of specialized intervention in which the child is actively and productively engaged in meaningful activities (National Research Council) can be challenging. Federal regulations under Part C of the Individuals with Disabilities Education Act (IDEA, 2004) mandate early intervention services for infants and toddlers with disabilities are provided in natural environments to the maximum extent appropriate. A child's natural environment includes the familiar routines and people in his or her typical, everyday activities. Thus, creating opportunities for instruction and systematic practice in the context of naturally occurring routines and activities in the child's life, or embedding intervention, is an important element to achieving sufficient dosage, or intensity of intervention. Embedding intervention into everyday activities and interactions across the day, rather than designating specific, decontextualized "therapy time," increases the opportunities a child has to practice functional, meaningful skills [31]. Consider the following strategy that caregivers and health-care professionals can use to increase embedded intervention in natural environments.

Identify regularly occurring routines or activities for embedded intervention throughout the child's typical day. Identify activities in which the child can play a meaningful, active role and work toward social communication goals. For example, can the family embed strategies to teach and reinforce gesture use during mealtimes or at the playground?

Suggestion 4: Use an Integrated Approach to Early Intervention.

In a review of interventions for children with ASD under the age of 3, Zwaigenbaum et al. [32] emphasized the need for a combination of early developmental and behavioral approaches. A developmental model emphasizes developmental sequence. For example, in Joint Attention Mediated Learning [10-14] parents facilitate toddlers' participation in progressively complex levels of engagement beginning with encouragement to look often and freely at the parent's face, building to responding to and initiating bids for social interaction. A behavioral approach utilizes analysis of observable antecedents and consequences to change behavior. Combination of developmental and behavioral models supports an integrated approach to target atypical or delayed development as well as functional communication in meaningful contexts. Consider the following strategies caregivers and health-care professionals can use to employ an integrated approach intervention.

Consider what the child needs to be able to do (developmental skills) in order to be able to change his or her communicative behavior. Then consider the child's current level of performance and strategies for shaping caregiver interaction and environmental supports.

To address challenging behaviors, first determine the function of the behavior and then teach an alternative more appropriate social communicative behavior to serve the same function or communicative intent. The table below illustrates the application of the above practical

suggestions to address stereotypic behaviors in a young child with ASD (Table 2).

Example of challenging or undesirable behavior	Possible antecedent	Function of the behavior or communicative intent	Functional communication training to teach an alternative more appropriate social-communicative behavior
Henry is a happy 2-year-old child with autism who spends a great deal of time waving his hands in front of his face. When he is left alone, he typically shakes his fingers in front of his eyes, while looking through them at light sources. His parents report that when he is engaged in this behavior, it is difficult to get his attention and that, in some instances, in the community, people will stare, make comments, or even tease Henry.	As part of a functional analysis Henry's parents report that Henry waves his hands in front of his face most often when alone or when not engaged in interaction with his parents or siblings.	This behavior may serve to communicate Henry's need for social or sensory stimulation. Waving his hands in front of his face may be Henry's means of communicating, "I'm overwhelmed" or "I don't know what to do." For Henry, this behavior is serving the function of helping him process this experience and sensation, abet in a manner that is not socially appropriate or communicative.	With the support of the early intervention team, Henry's parents teach Henry to replace the undesirable behavior (i.e., waving his hands in front of his face) with a socially appropriate communicative behavior (i.e., making a choice on a picture choice board). By attending to pictures on a choice board and communicating a choice of a desired object or activity, the undesired behavior is replaced by social communicative behavior. In order to teach choice-making behavior, the team first focuses on establishing joint attention and social reciprocity. They then teach Henry to touch or point to a picture to initiate a request and respond to his parents' communicative bids.

Table 2: Practical suggestions to address stereotypic behaviors in a young child with autism.

Summary

Early identification, as well as the timing and intensity of behavioral interventions are factors when working with young children with ASD. Research suggests that intervention provided during the critical period beginning before 3 years of age may lead to greater positive developmental outcomes. In this tutorial, specific and practical suggestions for caregivers and health-care professionals were provided including screening for early markers of autism spectrum disorder, encouraging active caregiver engagement in the intervention process, embedding intervention in natural environments, and using an integrated approach to early intervention.

References

1. American Psychiatric Association (2013) Diagnostic and Statistical Manual of Mental Disorders 5th Edition (DSM-5). Washington, DC: American Psychiatric Association.
2. Anderson DK, Lord C, Risi S, DiLavore PS, Shulman C, et al. (2007) Patterns of growth in verbal abilities among children with autism spectrum disorder. J Consult Clin Psychol 75: 594-604.
3. Kleim JA, Jones TA (2008) Principles of experience-dependent neural plasticity: Implications for rehabilitation after brain damage. J Speech Lang Hear Res 51: S225-S239.
4. Dawson G (2008) Early behavioral intervention, brain plasticity, and the prevention of autism spectrum disorder. Dev Psychopathol 20: 775-803.
5. Dawson G, Jones EJ, Merkle K, Venema K, Lowy R (2012) Early behavioral intervention is associated with normalized brain activity in young children with autism. Journal of the American Academy of Child and Adolescent Psychiatry 51: 1150-1159.
6. Fava L, Strauss K (2014) Response to Early Intensive Behavioral Intervention for autism--an umbrella approach to issues critical to treatment individualization. Int J Dev Neurosci 39: 49-58.
7. Sullivan K, Stone WL, Dawson G (2014) Potential neural mechanisms underlying the effectiveness of early intervention for children with autism spectrum disorder. Res Dev Disabil 35: 2921-2932.
8. Blatt G, Fitzgerald CM, Guptill JT, Booker AB, Kemper TL (2001) Density and distribution of hippocampal neurotransmitter receptors in autism: an autoradiographic study. Journal of Autism and Developmental Disorders. 2001: 537-543.
9. Blatt GJ (2012) The neuropathology of autism. Scientifica (Cairo): 703675.
10. Berger JM, Rohn TT, Oxford JT (2013) Autism as the Early Closure of a Neuroplastic Critical Period Normally Seen in Adolescence. Biol Syst Open Access 1.
11. Bradshaw J, Steiner AM, Gengoux G, Koegel LK (2015) Feasibility and effectiveness of very early intervention for infants at-risk for autism spectrum disorder: a systematic review. J Autism Dev Disord 45: 778-794.
12. Centres for Disease Control Autism and Developmental Disabilities Monitoring Network (2014) Prevalence of Autism Spectrum Disorder Among Children Aged 8 Years - Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2010 Surveillance Summaries 63: 1-21.
13. Church BA, Rice CL, Dovgopoly A, Lopata CJ, Thomeer ML, et al. (2015) Learning, plasticity, and atypical generalization in children with autism. Psychon Bull Rev 22: 1342-1348.
14. Courchesne E, Karns CM, Davis HR, Ziccardi R, Carper RA, et al. (2001) Unusual brain growth patterns in early life in patients with autistic disorder: an MRI study. Neurology 57: 245-254.
15. Courchesne E, Campbell K, Solso S (2011) Brain growth across the life span in autism: age-specific changes in anatomical pathology. Brain Res 1380: 138-145.
16. Desarkar P, Rajji TK, Ameis SH, Daskalakis ZJ (2015) Assessing and Stabilizing Aberrant Neuroplasticity in Autism Spectrum Disorder: The Potential Role of Transcranial Magnetic Stimulation. Front Psychiatry 6: 124.
17. Drew A, Baird G, Baron-Cohen S, Cox A, Slonims VS, et al. (2002) A pilot randomized control trial of a parent training intervention for pre-school children with autism. European Child & Adolescent Psychiatry 11: 266-272.
18. Friedman M, Woods J, Salisbury C (2012) Caregiver coaching strategies for early intervention providers: Moving toward operational definitions. Infants and Young Children 25: 62-82.
19. Giannopulu I (2013) Multimodal interactions in typically and atypically developing children: natural versus artificial environments. Cognitive processing 14: 323-331.
20. Harris SL, Handleman JS (2000) Age and IQ at intake as predictors of placement for young children with autism: a four- to six-year follow-up. J Autism Dev Disord 30: 137-142.
21. Individuals with Disabilities Education Act (2004) Part C, Sec. 631; 20 U.S.C. 1431 et seq.
22. Kana RK, Libero LE, Hu CP, Deshpande HD, Colburn JS (2014) Functional brain networks and white matter underlying theory-of-mind in autism. Soc Cogn Affect Neurosci 9: 98-105.

23. LeBlanc JJ, Fagiolini M (2011) Autism: a "critical period" disorder? Neural Plast 2011: 921680.
24. Mundy P, Neal R (2001) Neural plasticity, joint attention, and a transactional social-orienting model of autism. In L. Glidden (Ed.), International review of research in mental retardation: Autism New York: Academic Press.
25. National Research Council (2001) Educating Children with Autism. Committee on Educational Interventions for Children with Autism. Catherine Lord and James P. McGee, eds. Division of Behavioral and Social Sciences and Education. Washington DC: National Academy Press.
26. Pickles A, Anderson DK, Lord C (2014) Heterogeneity and plasticity in the development of language: a 17-year follow-up of children referred early for possible autism. J Child Psychol Psychiatry 55: 1354-1362.
27. Rogers SJ, Estes A, Lord C, Vismara L, Winter J (2012) Effects of a brief Early Start Denver Model (ESDM)–based parent intervention on toddlers at risk for autism spectrum disorders: A randomized controlled trial. Journal of the American Academy of Child and Adolescent Phychiatry 51: 1052-1065.
28. Schertz H, Odom SL, Baggett KM, Sideris JH (2013) Effects of Joint Attention Mediated Learning for toddlers with autism spectrum disorders: An initial randomized controlled study. Early Childhood Research Quarterly 28: 249-258.
29. Smith T (1999) Outcome of early intervention for children with autism. Clinical Psychology: Science and Practice 6: 33-49.
30. Stahmer A (2007) The basic structure of community early intervention programs for children with autism: Provider descriptions. Journal of Autism & Developmental Disorders 37: 1344-1354.
31. Wetherby AM, Guthrie W, Woods J, Schatschneider C, Holland RD, et al. (2014) Parent-implemented social intervention for toddlers with autism: an RCT. Pediatrics 134: 1084-1093.
32. Zwaigenbaum L, Bauman ML, Choueiri R, Kasari C, Carter A, et al. (2015) Early Intervention for Children With Autism Spectrum Disorder Under 3 Years of Age: Recommendations for Practice and Research. Pediatrics 136 Suppl 1: S60-81.