Neurological and Behavioral Distinctions between Autism & Sensory Processing Disorders

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Goals of the Presentation

Goal 1
To describe differences in the structural connectivity in children with Autism and children with Sensory Processing Disorder.

Goal 2
Provide examples of how sensory challenges impact behavior and learning in children with sensory processing disorders.

Goal 3
Discuss some biomarkers that show Neurological Differences between Autism and Sensory Processing Disorders.

Goal 4
Provide Examples of Interventions that are promising for maintaining an optimal state of arousal for self-regulation.

Trends in the Prevalence of Autism

[Graph showing Autism Prevalence Since 2000]
Alarming Statistics

• U.S. Department of Health and Human Services now estimates roughly 1 in 50 school-aged children are diagnosed with Autism Spectrum Disorder (ASD).
• CDC estimates about 1 in 68 children has been identified with autism spectrum disorder (ASD)
• ASD is not generally diagnosed until after three years of age.

Three Major Symptoms of Autism:

1. Impaired Social Interactions
2. Impairment in Communication both Verbal & Nonverbal communication
3. Restricted Interests, repetitive and stereotyped patterns of behavior.

Problem

1. Children diagnosed within the autism spectrum have unusual sensory processing issues.
2. Deficits in sensory processing are often described with behavioral descriptions (Tomchek & Dunn, 2007).
3. Approximately, 90% of children with Autism are reported to manifest disrupted sensory processing (Leekam, Nieto, Libby, Wing, & Gould, 2007).
Problem

4. Children with autism show impaired connectivity in the temporal tracts associated with auditory processing, social-emotional processing and attention.

5. Children with autism also show diminished connections essential to the processing of facial emotion and memory (Bunim, 2014).

6. Clinical observations, parent reports and behavioral studies suggest a complex and highly variable phenotype across the spectrum.

Perception of Faces
Observed Differences

<table>
<thead>
<tr>
<th>Children with Autism</th>
<th>Typically Developing Children</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Image 202x539 to 236x570" /></td>
<td><img src="image2.png" alt="Image 91x548 to 146x585" /></td>
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<td><img src="image3.png" alt="Image 184x591 to 227x633" /></td>
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<td><img src="image5.png" alt="Image 231x594 to 284x634" /></td>
<td><img src="image6.png" alt="Image 110x320 to 141x352" /></td>
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Calming Children with Autism

**Soothability**
The difference was significant between groups for time taken to get child to stop crying, \( t = -2.92, p = .006 \), with mothers of children on the autism spectrum reporting taking more time to get their child to stop crying.

**Comforting**
A significant group difference in the level of difficulty in providing comfort, \( t = -2.18, p = .034 \), mothers of children on the autism spectrum reported more trouble comforting their children than mothers of typically developing children.

Calming Children with Autism

**Hugging**
Significant group differences were found for hugs, \( t = 2.79, p = .011 \), with more mothers of typically developing children reporting hugging as a successful method of comfort.

**Music and Visual**
Mothers of children with autism were significantly more likely to report music \( t = 2.68, p = .011 \) and television/video \( t = -2.66, p = .011 \) as successful in comforting their children.
Gold Standard Assessments In OT

- The Short Sensory Profile (SSP) McIntosh, et. al.1999
- The Sensory Integration and Praxis (SPIT) Ayres, 1989 for assessing sensory Integration and Praxis (Schaaf et al.2014)

New Developments

- Recent neuroscience imaging studies have revealed distinct differences in neuronal connections that regulate behavior in children with autism and children with sensory processing disorders (Marco, Khatibi, Hill et al., 2012; Yi-Shin Chang, Owen, Desai, et al., 2014).
- Clinical studies have been inconsistent in revealing differences in somatosensory processing in children.
- About one percent of children in the United States are diagnosed with an autism spectrum disorder while five to 16 percent of children have sensory processing disorders (Mukherjee, 2015).
- Many studies have focused on auditory and visual sensory processing; few have explored early tactile processing despite the high prevalence of atypical tactile behaviors in children with ASD (Marco, et al., 2011).

Assessments for Autism

1. Autism Diagnostic Observation Schedule (ADOS)
2. Autism Treatment Evaluation Checklist (ATEC)
3. Modified Checklist for Autism in Toddlers (M-CHAT)
4. Test for Variables of Attention (TOVA)
5. Social Responsiveness Scale (SRS)
6. Sensory Profile Short Form
Autism Diagnostic Observation Schedule (ADOS)

- “Gold Standard” for Psychologist’s
- Mainly Observational
- Evaluates in four modules: behavior, communication, social interaction, play and imaginative use of materials
- Children with sensory processing disorders are often included in the Autism Category on the Diagnostic and Statistical Manual (DSM 5) used by psychologists and psychiatrists.

Dr. Winnie Dunne’s Research on Sensory Processing


Sensory Processing In Children With and Without Autism AJOT, 2007

Scott D. Tomchek, PhD, OTR/L, FAOTA
Weisskopf Center Louisville, KY 40202

Winifred [Winnie] Dunn, PhD, OTR, FAOTA
University of Kansas Medical Center
Sensory Profile

- Evaluates the child’s threshold for **Sensory Processing**:
  1. Auditory
  2. Visual
  3. Vestibular
  4. Touch
  5. Oral

Olfactory Sense in Autism


1. One of the most affected senses seems to be olfaction, whose role as a biomarker of neural functioning is well known. For this reason, the relationship between olfactory function and Autism has been investigated from a scientific point of view.

2. The vast majority of Autistic participants show an olfactory dysfunction, especially concerning the Olfactory Identification task, while others show an increase in their sense of smell.
Projections from the Amygdala to the Brainstem, via the Hypothalamus, Regulate the Expression of Autonomic Reactions to Social Signals


Vasopressin Linked with Dysfunctions in Sensory Processing

- Vasopressin neurons in the olfactory system may modulate input, sending information about smells to influence activation and mood.
- Vasopressin may be essential for integration of sensory input during complex forms of social behavior in mammals.
- Children with Autism with low vasopressin levels performed poorly on ability to perceive the perspectives of others.

The Role of Vasopressin in the Social Deficits of Autism

- Neuropeptides, such as vasopressin and oxytocin, are molecules used by neurons in the brain to communicate with one another. Vasopressin is closely related to oxytocin, which is currently being tested as a treatment for autism, and has been shown to enhance social functioning in animals.
Oxytocin and Autism

Oxytocin levels influence
- Social behavior,
- Communication
- Social bonding.
Nasal spray containing oxytocin improved social behavior.


Autism’s Gut-Brain Connection

- The different gut bacteria in autistic individuals may be contributing to the disorder.
- Researchers at the California Institute of Technology have shown for the first time that they may actually contribute to the disorder.

Brain-Gut Relationship

- Knowing at the “Gut Level”
  - The enteric nervous system contains some 100 million neurons, more than in either the spinal cord or the peripheral nervous system.
  - The enteric nervous system uses more than 30 neurotransmitters, and produces 95 percent of the body’s serotonin.
  - About 90 percent of the fibers in the Vagus nerve carry information from the gut to the brain.
Excess Stress & Cortisol Levels

- Studies show mothers of children with autism have high levels of stress.
- Impaired cognitive performance
- Lowered immunity and inflammatory responses in the body, slowed wound healing, and other health consequences.

Sensory Processing Disorders

Sensory Processing Disorder

Symptoms
- Warned by varied clothing fabrics.
- Usually high & low pain threshold.
- The patients are mostly worried by lights.
- Very much distressed by light or sudden touch.
- Excessively sensitive to sounds, including the volume and frequency.

Visit: www.slpassist.com
DSM-5 Diagnostic Criteria

Over 90% of children with Autism Spectrum Disorders (ASD) demonstrate atypical sensory behaviors.
In fact, hyperactivity or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment is now included in the DSM-5 diagnostic criteria.

Imaging Studies as Biomarkers

Brain changes in the hippocampus in children with autism suggest that this might be an important target for brain-based treatments, including both therapy and medication.

Imaging the Brain

[Image of structural and functional brain maps]
Diffusion Tensor Imaging

Traces the pathways of nerve fibers by measuring the diffusion of water molecules in the brain.

— vector.childrenshospital.org

Structural Connectivity in the Autistic Brain

• ASD group show impaired connectivity in temporal tracts associated with social-emotional processing.
• Sensitivity to sounds or Auditory processing has been associated with ASD in a number of studies.
• One prevailing hypothesis [about autism] is that there is an underconnectivity (Just et al., 2004) localized and overconnectivity of more distant sites (Anderson et al., 2011).

Biomarkers for Sensory Processing Disorders

• White matter microstructure is a biological substrate for the atypical sensory behaviors of children with SPD.
• Social impairments in autism are likely caused by the poor frontal-posterior connectivity.
• Studies of white matter may also help to establish SPD as a clinical entity distinct from overlapping conditions such as autism spectrum disorders and ADHD.
• In the case of autism, the connections between different brain regions are altered, and not altered evenly, which means to the ability of the brain to process information is impaired.
Is the White Matter Neuroplastic?

Neuroimaging studies of visuomotor learning in humans have suggested that structural plasticity can occur in white matter (WM), but the biological basis for such changes is unclear.


Researchers at four study sites nationwide used a type of MRI scan to look at brain development in the younger siblings of autistic children, who are known to be at higher risk for autism themselves.

— news.stlpublicradio.org

Imaging Studies Showing Hypoperfusion in Temporal Lobes in Children with Autism Spectrum Disorder
Diffusion Tensor Imaging Study UCSF

Elysa Marco, MD
University of California San Francisco

- Children with sensory processing disorders have overgrowth of brain’s white matter which is essential for perceiving, thinking and learning.
- Trouble with Emotional Regulation and Attention

White Matter Correlates of Sensory Processing in Autism
Diffusion Tensor Imaging was used to examine white matter fiber tracts associated with aberrant sensory processing.
N=32 ASD
N=26 TDC
1. Inferior Longitudinal fasciculus which plays a role in tactile defensiveness.
2. Splenium involved in attentional orienting
White Matter Microstructural Integrity

This imaging biomarker not only presents an ideal diagnostic tool to be used in conjunction with other parent reports and direct behavioral measures, but also informs treatments based on cognitive rehabilitation. Children with Sensory Processing Disorders (SPD) have impaired white matter microstructure, and that this white matter structural connectivity correlates with atypical sensory behavior.


Splenum of the Corpus Callosum

White matter modulates the distribution of action potentials, acting as a relay and coordinating communication between different brain regions. The splenium fibers, affect the interhemispheric synchronization of neural networks.
Splenum means Bandage

Citation


Splenium of the Corpus Callosum

- Allows modulation of responses to superfluous information from the visual environment, leading to a reduction of metabolic and structural redundancy in a child's brain.
- The size of the Corpus Callosum in animals and humans increases with learning or training.
Splenum of the Corpus Callosum

- One such function is figure-ground segregation, which refers to the ability of the visual system to segment images of the external world into objects and background.
- It relies on inhibition among neurons with neighboring receptive fields tuned to the same feature.
- The functions of the splenium may encompass communication among different levels of hierarchy.

Splenum of the Corpus Callosum

The impact of the splenium in synchronizing the electrical activity between the hemispheres is supported by animal models and noninvasive human studies.

fMRI Images showing Interhemispheric integration in children and Adults

- Myelination facilitates interhemispheric interaction by enhancing the coordination of interhemispheric input.
- The Splenium is slow to Myelinate
- Continuing development leads to the cortex rewiring through elimination of overproduced connections.
Study Links Brain Size to Regressive Autism

Consistent with postmortem and head-circumference studies, brain imaging studies suggest that overall brain volumes are increased in children with autism (David Amaral-MIND Institute at the University of California, Davis).

Cortical Connectivity

These abnormalities suggest aberrant connections between cortical regions, is consistent with the hypothesis of abnormal cortical connectivity in autism.

The Thickness of the Corpus Callosum is Reduced in Autism

Citation


Event Related Potential

Electroencephalography (EEG) provides an excellent medium to understand neurobiological dysregulation, with the potential to evaluate neurotransmission. Time-locked EEG activity or event-related potential (ERP) helps capture neural activity related to both sensory and cognitive processes.

WHAT IS EVENT-RELATED POTENTIAL?

- Event-related potentials (ERPs) are very small voltages generated in the brain structures in response to specific events or stimuli (Blackwood and Muir, 1990).
- Event-related potentials can be elicited by a wide variety of sensory, cognitive or motor events. They are thought to reflect the summed activity of postsynaptic potentials produced when a large number of similarly oriented cortical pyramidal neurons (in the order of thousands or millions) fire in synchrony while processing information (Peterson et al., 1995).
EVENT-RELATED POTENTIAL

• ERP constitutes a millisecond-by-millisecond record of neural information processing, which can be associated with particular operations such as sensory encoding, inhibitory responses and updating working memory. Thus it provides a noninvasive means to evaluate brain functioning in persons with cognitive disorders.

Event-Related Potential (Auditory, Visual, or Tactile).

https://www.youtube.com/watch?v=iteBq04-UQY

Study Used 70 Electrodes

Study found that children diagnosed with autism process auditory input less effectively than typically developing children.

Severity Scores: N1a & N1b

Children with Sensory Processing Disorder (SPD)

- Aberrant connectivity in the pathways that serve Auditory, Somatosensory and Visual attention.
- Children with SPD have difficulty processing incoming sensory input.

Neuroplasticity

Myelination in the nervous system is a plasticity-dependent process.
Enriched Environments and Sensory Input Promotes Dendritic Growth.

Touch Pressure Removes Biochemical Substances in Soft Tissues: Vasopressin Levels Reduced

Deep Pressure on Primary Rami

Qigong Massage Program

OT’s can help families understand that children with autism have unique styles of sensory processing that influence their behavior in the parent-child relationship.


Music is Globally Processed in the Brain

Elements such as rhythm affect physiological and developmental functions


Occupational therapists use music as preparation for therapeutic activities on the basis of the belief that sensory input through the auditory and vestibular systems can be calming and organizing to children (Ayers, 1979; Frick & Hacker, 2001).

Dr. Jane Case-Smith, EdD, OTR/L, FAOTA

Dr. Alfred Tomatis, a French physician and researcher theorized that the ear is an integrator for the entire nervous system and that we listen with our whole body. The ear affects the body’s ability to integrate information for hearing, listening, motor control, communication, and learning, and helps bring about cortical impulses in the brain.

Children with Autism

- Have decreased connectivity in the Inferior Longitudinal fasciculus, Inferior front-occipital fasciculi, fusiform amygdala and the fusiform-hippocampus.
- Difficulty Processing Socio-emotional Input

Music Promotes Plasticity of the Corpus Callosum & Longitudinal Fasciculus


"Training before the age of 7 years results in changes in white-matter connectivity that may serve as a scaffold upon which ongoing experience can build."

Auditory Processing and the Nucleus Basalis

Main subcortical source of cortical acetylcholine (Ach) which is associated with speed and strength of synaptic connections.

Acetylcholine accelerates Activity-dependent neuroplasticity & neurodevelopmental.

Therapeutic Applications

Children with Autism become socially engaged when they mouth words & rhythms.

Oscillation Activity in the Brain

- The network activity of the brain is oscillatory in nature.
- Oscillations provide a temporal frame for neuronal firing by means of synchronization of pre- and postsynaptic potentials.
- In the context of this discussion, oscillations in the EEG alpha rhythm are of special interest.
EEG brainwaves

Monitoring Brain Waves (EEG’s)

EEG Studies to Diagnose Autism

EEG’s are more accurate than behavioral assessments to diagnose Autism.
**Why EEG’S**

http://www.ted.com/talks/aditi_s_hankardass_a_second_opinion_on_learning_disorders.html

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**Alpha Rhythm**

- Alpha rhythm is the most prominent oscillatory activity that can easily be recorded by means of noninvasive surface EEG electrodes within a wide range of ages.
- Alpha waves are generated by visual cortical circuits interacting with thalamocortical loops.
- Alpha waves operate within a relatively narrow frequency range between 8 and 12 Hz.

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**Alpha Rhythm in Children**

- The development of alpha rhythm in children seems to be closely linked to the maturation of the Corpus Callosum.
- Alpha Rhythms are patterns of smooth, electrical oscillations in the brain that reflect a transcendent and dynamic state of consciousness.
Protocols Rewarding 12-15 HZ at the Temporal lobes at Sites T3 and T4

The Neurofeedback Signal is derived from assemblies of Pyramidal Cells located on the outer surface of the cortex (Electrical Potentials)

Neurofeedback Training

Neurofeedback trains the brain to self-regulate brain oscillations leading to improved attention and social responsiveness. The specific areas of the brain affected by Autism can also be targeted and trained to produce higher frequencies brainwaves.
Predominant Brain Waves Influence Behavior

Test for Variables of Attention (TOVA)

**Continuous Performance Test:**

1. **Response Time Variability** - measures inconsistency or inability to stay on task.
2. **Commission Errors** - measures impulsivity or dys-inhibition or incorrect responses to non-target.
3. **Omission Errors** - Measures inattention when child does not respond to designated target.
4. **Performance over time** - measures response to signal detection over four quadrants of time.

Test for Variables of Attention (TOVA)

- Continuous Performance test
- Provides objective measures of child's performance on visual attention tasks over time (21.6 minutes).
- Measures response time on an electron micro switch in milliseconds.
Six-months post-intervention, gains were maintained in the neurofeedback group, but not in the cognitive training group.


Increased Attention

Activities that engage attention seem to improve the ability to develop language skills.
Social Responsiveness Scale (SRS)

Parent & Teacher rating scale
Measures
1. Social Awareness
2. Social Cognition
3. Social Communication
4. Social Motivation
5. Autistic Mannerisms

Brain Computer Interface Game Applications- UC San Diego

Transcranial Direct-current Stimulation
Transcranial Direct-current Stimulation

Schneider, H, 2010
“We feel that tDCS is a useful therapeutic intervention particularly for children that have autism with language difficulties”

In combination with functional MRI investigational research being completed at New York City (Columbia University Program for Imaging and Cognitive Sciences).

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Chewing Gum Auditory Stress

- Noise activated the bilateral superior temporal sulcus and the left anterior insula.
- Gum chewing inhibited the connectivity to the bilateral superior temporal sulcus and the left anterior insula.
- Anterior Insula and the dorsal anterior cingulate cortex was affected to a lesser extent when chewing gum.


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OT Areas of Occupation

- Rest and Sleep in OTPF
- *Rest* induces a relaxed state and renewed interest in engagement.
- *Sleep preparation* - establishing sleep patterns
- *Sleep Participation* - sustaining a sleep state without interruption.

Nedergaard and Colleagues of Rochester University

The main detoxifying system in the brain consists of the cerebrospinal fluid (CSF) that is produced by filtration through the brain arteries into the surrounding spaces, and circulates among the brain structures.

Researchers found that the space inside the brain increases by **60 percent** during sleep.

Prognosis for Autism

- No Cure at the Present Time
- Early intervention may reduce undesirable behaviors
- Treatments & interventions are aimed at specific symptoms in each individual (highly variable).
- Best practices and outcomes are achieved with a **team** approach
Studies on Recovery

• Clinical Study at the University of Connecticut shows a small percentage of children recover as a result of intensive interdisciplinary therapy in a sample of 34 participants.

Prognosis

• Autism is not curable but is treatable
• Symptoms improve with early intervention
• Ivar Lovaas (UCLA) saw 47 percent recovery with intensive behavioral therapy.
• Some will lead normal or near-normal lives
• Symptoms may get worse in adolescence

Questions?

Neurological and Behavioral Distinctions between Autism & Sensory Processing Disorders
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Selected References


