Current Evidence-Based Identification Patterns of Sensory Integration Dysfunction in Specific Populations

Shelly Lane Ph.D., OTR/L, FAOTA
Zoe Mailloux, OTD, OTR/L, FAOTA
Stacy Reynolds, Ph.D., OTR/L
Susanne Smith Roley OTD, OTR/L, FAOTA

Sensory Integration
Special Interest Section
AOTA Annual Conference & Exhibition
Nashville, TN April 2015

The Constructs
• How did ASI develop over time?
• How did research serve to form constructs?
• What patterns of sensory integrative function and dysfunction are understood now?

Ayres Sensory Integration
• Early model identified sensory and motor constructs which provide the foundation for occupation
• Beginning in the 1960s, systematic test development and theory building established the relationships between the constructs in both typical and special needs populations

Patterns of Sensory Integration Function and Dysfunction: Identified by Ayres through Systematic Analyses & Expanded Upon By Other Researchers

Sensory Integration Patterns Demonstrated in Studies (1965-2015)
• Somatosensory
• Somatopraxis - tactile + motor planning deficits
• Visuopraxis
• Vestibular, bilateral integration & sequencing
• Sensory Reactivity - Tactile defensiveness & attention
• Praxis on Verbal Command

Ayres (1989)
Typically Developing Children & Children with SI/LD
• Somatopraxis/somatodyspraxia
• Visuopraxis/visuodyspraxia
• Bilateral integration & sequencing*
• Somatosensory perception
• Dyspraxia on Verbal Command*

* Found only in LD/SI groups
Mulligan (1998)
Large sample of children presumed to be mostly children with identified SI concerns
- Bilateral integration & sequencing
- Somatosensory
- Visuopraxis
- Dyspraxia
** these four patterns were also closely related to one another suggesting underlying generalized SI dysfunction

Mulligan (1996)
Children with and without ADHD
- Children with ADHD demonstrated weaknesses with vestibular processing and in most areas of praxis
- Fewer differences seen in non-motor visual perception and localization of tactile input

Children with SI concerns
- Visuo & Somatodyspraxia
- Vestibular/Proprioceptive Bilateral Integration & Sequencing
- Tactile & Visual Discrimination
- Tactile Defensiveness & Attention Issues

Koester, Mailloux, Coleman, et al. (2014)
Children with Cochlear Implants
- Significant differences found between children with CIs and the normative population on the majority of the SIPT tests associated with the vestibular and proprioceptive bilateral integration and sequencing (VPBIS) pattern
- Problems in sensory reactivity, somatopraxis or visuopraxis not present in this cohort

van Jaarsveld, Mailloux, Smith Roley, & Raubenheimer (2015)
South African Children with SI Concerns
- Visuo and Somatodyspraxia
- Bilateral Integration and Sequencing
- Sensory Perception (Tactile/Visual Discrimination)

Lane, A.E. et.al. (2010)
Children with ASD
Found 3 patterns in sensory responsiveness
- Sensory-based inattentive seeking - under-responsive (milder overall)
- Sensory modulation with movement sensitivity - low energy/weak, poor endurance
- Sensory modulation with taste/smell sensitivity under and over-responsiveness with no movement issues more communication difficulties and maladaptive behaviors
Sensory subtypes
predicted communication competence and maladaptive behavior
Children with ASD
• Marked difficulties evident in somatopraxis, vestibular bilateral integration, somatosensory perception, and sensory reactivity
• Relative strengths in visual perception

Summary
• Main patterns are consistent and reflect associations of some underlying sensory motor functions (e.g. tactile perception and praxis; vestibular and bilateral functions, sensory reactivity and attention)
• Some patterns are more prevalent than others in specific populations
• Most research to date has not considered all sensory integration constructs - sensory perception, bilateral integration, praxis and sensory responsiveness - together in the same study

Research in Children with ADHD
Sensory Overresponsivity and Anxiety in Children With ADHD

ADHD Subtyping
Proposed Type 1
• ADHD- hyperactive/impulsive or combined type
• Disruptive Behavior
• Oppositional Defiant Behaviors
• Sensation Seeking
• Biomarker: Blunted response to sensory stressor

Proposed Type 2
• ADHD- inattentive type
• Anxiety
• Sensory Sensitive
• Sensory Avoiding
• Biomarker: Elevated and extended release of cortisol, as well as heightened sympathetic measures.

Using physiology to test sensory-based subtypes
**Models Linking SOR with Anxiety in Autism** (Green & Ben Sasson, 2010)

![Diagram of Models Linking SOR with Anxiety in Autism](image)

**Physiological Patterns in ASD**

- **PNS Activity - Decreased**
  - Hostility
  - Aggressive Behavior

- **SNS Reactivity - Increased**
  - Eye-gaze aversion
  - Over-responsive reactions to sensory stimuli
  - Anxiety

- **HPA (Cortisol) - Variable**
  - Sleep Problems

**Patterns of Responsivity across Diagnostic Groups**

*Patterns of Responsivity and Anxiety in Typically Developing Children and Children With Autism and Attention Deficit Hyperactivity Disorder: Cause or Coexistence?*

*Sherry J. Lane, Stacy M. Reynolds, Lennart Oyeronos*

*The American Journal of Occupational Therapy*

**Sensory-Based Subtyping in ASD** (Lane et al, 2014)

**Sensory Integration Patterns in Children with Autism Spectrum Disorders**

"Our model suggests that the magnitude of responsiveness to a sensory challenge determines both the ability of the nervous system to recover from the challenge, in this case return to baseline following the perceived threat of unpredictable and uncontrollable sensory challenge, and generalized anxiety..."
Autism Spectrum Disorder

DSM-V; APA, 2013

299.0

Restricted repetitive activity to patterns of behavior, interests, and activities (at least two of the following)

- Stereotyped repetitive movements, use of objects, speech
- Insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal nonverbal behavior
- Highly restricted, fixated interests that are abnormal in intensity or focus
- Hyper-hypo reactivity to sensation or unusual interests in sensory aspects of the environment

Sensory perceptual differences in ASD were noted in Ayres early work and confirmed by Ayres, 1989

SIPT ASD study

vestibular, motor and praxis scores significantly low
relatively high visual perceptual scores

Sensory differences in ASD predominantly feature atypical sensory reactivity

Ayres & Tickle, 1980

Children with over-responsiveness responded better to SI intervention

Gowen and Hamilton, 2012

While motor learning in ASD relatively intact,

Findings indicate poor integration of information for efficient motor planning, increased variability in basic sensory inputs and motor outputs

Atypical Sensory Reactivity

Primarily identified via sensory history questionnaires

Ben-Sasson et al., 2007
Dunn, Myles, Orr, 2002
Crane, Goddard, & Pring, 2009
Lane, Young, Baker, & Angley, 2010
Liss et al. 2006
Schoen, Miller, Brett-Green, & Nielsen, 2009
Tomchek & Dunn, 2007
Watson et al., 2011
Woodard et al., 2012

Motor & Praxis Concerns in ASD

Jones & Prior, 1985
Ayres, 1989
Mostofsky et al., 2006
Dziuk et al., 2007

imitation gestures to command tool use
Social difficulties characterizing ASD are commonly accompanied by sensory, motor, and praxis deficits

- Ben-Sasson, Fluss, & Cermak, 2008
- Dziuk et al., 2007
- Marco, Hinkley, Hill, & Magarajan, 2011
- Mostofsky et al., 2006
- Siaperas, Ring & McAllister, 2011

**Implications for Early Identification of ASD**

- Sensory Responsiveness
  - Over responsiveness
  - Under responsiveness
  - Fluctuating responsiveness
  - Poorly regulated behaviors

- Vestibular-Proproprioceptive Processing
  - Security with Movement
  - Seeking rotation and watching things spin
  - Postural Control
    - Head
    - Sitting
  - Praxis
    - Tool use
    - Exploration of body parts
    - Imitation
    - Sequencing
    - Ideation and complexity in play
    - Following unfamiliar instructions

**Theoretical Models of Sensory Integration**

**FUNCTION**
- Ages: 1979, 2005
  - Classic Model of Sensory Integration and typical development

- Smith, R. L. & Spitz, 2001
  - Model of SI and development relative to occupational science and therapy

**DISFUNCTION**
- Bundy, Murray, & Lane, in press
  - Patterns of SI and praxis deficits

- Miller et al., 2007
  - Sensory Processing Disorder proposed nosology

- Smith, R. L., 2006; revised based on Mailloux, et al., 2011
  - Analysis of Patterns of SI Dysfunction

**Sensory Integration Patterns in ASD**

Roley, Mailloux, Parham, Scharf, Lane, & Cermak, 2015

**Visual Praxis – Strength** in motor free visual perception and visual construction

**Somatosensorypraxis**

Somatosensory processing of tactile and proprioception
Dyspraxia including poor imitation, sequencing, and following unfamiliar instructions

**Vestibular-related challenges**

Standing, Walking, Balance below average, oftentimes low postrotary nystagmus and poor postural control

**Atypical Sensory Reactivity**

Heightened responses to a variety of stimuli, atypical pain responses with under-responsiveness to body-centered sensations

*Dyspraxia* more predictive of Social Participation Deficits than sensory reactivity (SPM) or language processing (PrVC)

**Correlations Among SIPT functions and SPM scores for Children with ASD**

Roley, et al. 2015

<table>
<thead>
<tr>
<th>SPM</th>
<th>SIPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-Home</td>
<td>Vis</td>
</tr>
<tr>
<td>C-Main Classroom</td>
<td>Perc</td>
</tr>
</tbody>
</table>

| Social – H | ** | * |
| Social – C | *** | ** | * |
| Planning-Idea-H | ** |
| Planning-Idea-C | * |
| Total Sensory-H | ** |
| Total Sensory-C | ** |

*p<0.05, **p<0.01, ***p<0.0001*
Model of Sensory Integration

Dunn’s model, emphasizing the interplay between neurological threshold and behavior

Sensory Processing Disorders

Sensory Modulation Disorder
- SOR: Sensory Over-responsive
- SUR: Sensory Under-responsive
- SS: Sensory Seeking/ craving

Sensory Based Motor Disorder
- Posture
- Praxis

Sensory Discrimination Disorder
- Vestibular
- Proprioception
- Tactile
- Auditory
- Visual
- Olfactory
- Gustatory

Miller et al., 2007

Together they

- Provide a continuum from function to dysfunction
- Guide us in looking beyond easily observable behavior
- Provide foundation for interpreting what we observe
- Establish a foundation for planning intervention
- Help us predict how behavior may change as a result of intervention
What is the clinical relevance?

• Patterns of test scores
  – Guide us in using well established assessment tools as a means for understanding clinical populations
  – Substantiate differences in sensory integrative disorders within and across populations
  – Establish a basis for choosing an intervention approach, establishing goals, planning treatment, and determining outcomes

Future Directions

• Early identification of sensory integration and praxis abilities/disabilities
• Early intervention
• Improved statistical power in treatment studies
  – Homogeneity of sample
  – Larger sample sizes

Future directions

• Better understanding of the best responders to ASI Intervention
• Examination of treatment “dose” - i.e. duration, frequency, intensity
• Identification of salient outcomes for the individual and their caregivers

Unanswered questions...

• Patterns of test performance do not tell us directly about treatment effectiveness
  – Pfeiffer, et al, 2011; Schaaf, et al, 2013 RCTs provide guidance here
• In clinical populations we do not yet know if sensory integrative concerns are core or symptom
• Unclear still how physiologic patterns mesh with assessment patterns, and how they may be changed by treatment

THANKS FOR YOUR ATTENTION!
QUESTIONS?
Current Evidence-Based Identification of Patterns of Sensory Integration Dysfunction in Specific Populations

Shelly Lane, Zoe Mailloux, Stacey Reynolds, & Susanne Smith Roley

SISIS Annual Meeting AOTA, 2015


