Brain & Sensory Processing Differences Across the Lifespan

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Today’s presentation

Sensory processing
Brain development
Sensory systems and aging
Limitations & Future directions
Sensory Processing

• Most of us are familiar with the five senses: sound, sight, taste, smell, and touch

• There are other sensory systems also:
  
  • Vestibular: movement and balance
  
  • Proprioception: where our body is in space
  
  • Interoception: understand what is happening inside our body
Sensory processing differences in autism

- The Diagnostic and Statistics Manual (DSM-5) includes sensory issues as part of the diagnostic criteria for ASD
- “experiencing the sensory aspects of the world in an unusual or extreme way”
  - indifference to pain/temperature
  - excessive smelling/touching of objects
  - fascination with lights and movement
  - being overwhelmed with loud noises
93 to 96% of children on the spectrum & autistic youth experience sensory processing differences to such an extent that they significantly impact daily functioning.

Ben-Sasson et al., 2008; Tomchek et al., 2014
Sensory processing in adults with autism spectrum disorders

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Abstract
Unusual sensory processing has been widely reported in autism spectrum disorders (ASDs); however, the majority of research in this area has focused on children. The present study assessed sensory processing in adults with ASD using the Adult/Adolescent Sensory Profile (AASP), a 60-item self-report questionnaire assessing levels of sensory processing in everyday life. Results demonstrated that sensory abnormalities were prevalent in ASD, with 94.4% percent of the ASD sample reporting extreme levels of sensory processing on at least one sensory quadrant of the AASP. Furthermore, analysis of the patterns of sensory processing in adults with ASD revealed distinct profiles compared to typically developing adults.

Keywords: autism; sensory processing; Sensory Profile

Sensory difficulties across the lifespan
The Relationship Between Autistic Traits and Atypical Sensory Functioning in Neurotypical and ASD Adults: A Spectrum Approach

Sensory symptoms

Autism traits
Optimal attention and arousal

Rolling down the window wakes me up

Alert

Calm

Deep breaths help calm me down
Chewing on things with different textures helps me feel more alert.

Hyperreactivity avoids sensory input.

Hyporeactivity seeks out sensory input.

Using noise-cancelling headphones helps me calm down.
How do autistic individuals experience sensory information?

- Hyperreactivity: Overwhelmed by sensory information

- If you can’t filter out the sensory information that doesn’t matter, then you can experience “overload”

Image taken from National Autistic Society’s “Too Much Information” campaign
How do autistic individuals experience sensory information?

- Hyporeactivity: Underwhelmed by sensory information
- Things that should hurt/be annoying are not (injuries, loud music, hard hugs, etc.)
- Seeks out sensory experiences (climbing, swinging, jumping, etc.)
In their own words:

• “Bad smells feel quite **painful**”

• “Strip lighting . . . that can immediately . . . **hurt** a lot”

• “Loud noise can bother me . . . and it can feel **painful**.”

• “If textures (of food) were mixed . . . the sensation makes me want to feel **physically ill**.”

• “People brushing past me . . . it’s like **pain mixed with panic** . . . and I can become quite aggravated because of it”

Quotes from adults with ASD taken from Robertson & Simmons, 2015
Neuroscience & Sensory Seeking Behaviours

- Homunculus: Visual representation of the brain dedicated to sensory systems for parts of the body
- Greatest density of tactile receptors in hand, mouth & genitals
- Sensory seeking activity will usually be focused on the ‘bigger’ parts of the body

https://nobaproject.com/modules/touch-and-pain
Types of receptors in the skin

Image taken from AIDE Canada’s Sensory Processing Differences Toolkit
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Limitations & Future directions
The brain develops in layers in the womb.

Neurons (brain cells) talk to each other through synapses (connections).

We are born with billions of synapses and will lose the ones that we don’t use.
Layers In The Brain

- Imagine you are at the ocean
- As you travel to higher elevations you will come across different ecosystems
- Each ecosystem has different plants and animals that are adapted for the challenges in that unique ecosystem
- Plants or animals that are moved to higher elevations can interrupt the balance of the new ecosystem
Brains of people with ASD show differences starting in the first 3 months in the womb.

The brain develops in layers, and some cells in one layer are migrating to other layers within the first trimester in ASD. Image taken from Orosco et al., 2014.
Neuronal migration differences in humans

• Some (NOT ALL!) brains of people with ASD also show atypical neuronal migration

• The dark purple cells in layer “G” have migrated into layer “M”

• These differences may contribute to sensory processing issues

Image taken from Wegiel et al., 2010
Connections between cells in the brain (neurons) are also different

- When we are born, we have lots of connections between cells (synapses)
- As we develop, the brain removes the connections we don’t need (called “synaptic pruning”)
- In ASD, we see more connections between cells that are close to each other, which means there is a “failure to prune”

Image taken from Tang et al., 2014
What does this mean?

• Imagine you are in a dense forest

• If you go in the same direction over and over, you will eventually create a path

• If you take that same path day after day, that path will turn into a trail

• With more “traffic” the trail will become a gravel road, then a one-lane street, then a highway, etc.

• Paths that are not taken will eventually become overgrown
What is different in ASD?

• The brains of people with ASD keep extra paths that are not necessary (they do not become overgrown)

• This means there are lots of paths next to each other “talking” at the same time

• Less energy can go towards making those big highways for the important things (like getting one part of the brain to “talk” to another part that is further away)
How do these extra paths lead to sensory issues in ASD?

• In children, we see extra connections in areas close to each other, including sensory areas used for vision, hearing, etc.

• With extra connections, it is harder for the brain to “filter out” the sensory information that isn’t important

Image taken from Supekar et al., 2013
What about long-distance connections between areas of the brain?

- We see weaker connections (thinner lines) in areas far apart from each other, including sensory areas and their connections to the “social” parts of the brain.

- With weaker long-distance connections, it is harder for the brain to make sense of what it is seeing/hearing/feeling.

Image taken from Kana et al., 2014
Multisensory Issues in ASD

• Multisensory means more than one sense being used to process an event

• Looking at a person’s face while they are talking

• Tasting food and feeling its texture in your mouth when you eat

• Smelling shampoo while your fingers rub it into your scalp when washing your hair

Putting two or more senses together at once = multisensory integration
Multisensory integration

• Research has shown that some autistic children have trouble putting sound and sight together at the same time.

• For these children, when a person talks it is almost always out of sync (their face and the words don’t match).

• This is why giving autistic individuals extra time to process what you said is so important!

Image taken from Watson & Platt, 2012

Multisensory integration areas of the brain are not showing as much activity in ASD.

Image taken from Watson & Platt, 2012
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Limitations & Future directions
Auditory (Hearing) System

- Matures: 6 months (basics), fine-tuned into late teens, degrades age 40+

- Signs of hyper-reactivity/over-responsivity: avoids certain sounds, startles easily

- Signs of hypo-reactivity/under-responsivity: bangs objects, shouts when speaking
Visual (Sight) System

- Matures: 4-5 years old (acuity), 30 years old (face processing), degrades age 40+

- Signs of hyper-reactivity: frequently covers eyes, covers part of the page when reading

- Signs of hypo-reactivity: difficulty finding objects in crowded environments, waves objects in front of face
Tactile (Touch) System

- Matures: At birth, but fine-tuned based on integration with other senses as they develop, degrades age 55+

- Signs of hyper-reactivity: resists physical touch, dislikes certain fabric

- Signs of hypo-reactivity: low reaction to pain, seeks deep pressure by pushing against others
Olfactory (Smell) System

- Matures: 3+ months (basics), degrades age 65+

- Signs of hyper-reactivity: avoids kitchen and bathrooms, reacts strongly to smells

- Signs of hypo-reactivity: seeks out strong odors, smells foods or objects
Gustatory (Taste) System

- Matures: constantly changing as we age, adult tastes in 20s, peaks late 30s, degrades dramatically age 60+

- Signs of hyper-reactivity: very particular about food textures, gags easily

- Signs of hypo-reactivity: chews or licks non-food objects, may ‘pocket’ food in cheeks
Vestibular (Movement & Gravity) System

• Matures: 15-16 years old, degrades age 60+

• Signs of hyper-reactivity: Resists activities where feet leave ground; avoids movement

• Signs of hypo-reactivity: craves movement, climbing, jumping; rocks/cannot sit still on the chair
Proprioception (Body Awareness) System

• Matures: 3-4 years old, degrades age 60+

• Signs of hyper-reactivity: Rare

• Signs of hypo-reactivity: Stomps when walking, gives hard ‘high-5s’, hangs on desk for support
Interoception (Internal Body Signals) System

- Matures: 9 months (basics), in tact by age 6, fine-tuned throughout adolescence, degrades 60+

- Signs of hyper-reactivity: Unusually low pain threshold, overly sensitive to temperature changes

- Signs of hypo-reactivity: Unusually high pain threshold, poor awareness of hunger, thirst, or need to use washroom
The Importance of Interoception

- Difficulty localizing pain can lead to serious health complications
- Difficulty recognizing signs of anxiety can lead to shutdown or burnout
- Involved in sensory processing, self-awareness, emotional guidance of social behaviour, and regulating the nervous system.

Insula receives and decodes interoceptive input from sensory receptors in our tissue, organs, bones, etc.
Sensory processing differences summary

• Some autistic individuals have more connections in the brain in sensory areas

• Some autistic individuals have weaker long-distance connections between areas that are far apart in the brain

• This combination of too many connections in sensory areas and weaker connections to other areas may lead to hyper- and hypo-reactivity to sensory information

• Some autistic individuals have trouble understanding information from multiple senses at once and need extra processing time to put the information together

• Our sensory systems change as we age, and we need more research to understand how that impacts autistic individuals across the lifespan
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Limitations

• Reproducibility Crisis
  • Researchers are not always able to replicate findings from previous studies
  • In autism research, may be due to heterogeneity in the autistic population
  • Only a subset of autistic individuals are able to tolerate testing conditions
  • Many measures of sensory processing are proxy/self-report questionnaires
Future Directions: Research

• Utilize technology that allow more autistic individuals to participate in experiments
  • Eye-tracking
  • EGI/EEG
  • Mock MRI scanners

• Design studies in collaboration and partnership with autistic individuals – “Nothing about us, without us”
  • Family Engagement in Research Course: KBHN & McMaster University
  • International Society for Autism Research (INSAR) Community Collaborator Request (ICCR)
Future Directions: Resource Development

• Collaborate with autistic individuals
  • Make sure autistic voices are front and centre
  • Collect feedback from variety of individuals
  • Make sure useful strategies are provided for the people who need it
Ready to Learn Interoception

- Developed by Dr. Emma Goodall and team with the South Australia Department of Education

- Activities delivered in all classrooms to teach interoception and self-regulation skills

- Reduced send-homes by roughly 80%

- Dr. Wenn Lawson is providing guidance to AIDE Canada to turn it into an online course (ETA June 2022)

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- Goodall, E. (2016) Interoception 101 Activity Guide, Department for Education, South Australia
- Department for Education Interoception resources
Sensory Processing Differences Toolkit

• Developed by Elsbeth Dodman (Autistic Self-advocate), Moira Pena (OT), and Fakhri Shafai (PhD, M.Ed.) on behalf of AIDE Canada

• Provides:
  • First-person autistic narrative of sensory experiences
  • Neuroscience background
  • Tips for how to become a “Sensory Detective”
  • Strategies to try at home
Interpreting Social Situations Interactive Video Course

• Developed by a team of autistic individuals and Fakhri Shafai (PhD, M.Ed.) on behalf of AIDE Canada

• All scenarios selected by autistic focus groups and team members as being confusing or stressful

• Autistic collaboration at every step (design, script writing, storyboard, main actor, editing)

• Provides practice for social interactions and tips on how to read facial expressions and body language
Final Thoughts

“Let’s give people with autism more opportunities to demonstrate what they feel, what they imagine, what comes naturally to them through humor and the language of sensory experience. As we learn more about autism, let’s not forget to learn from those with autism. There are poets walking among you and they have much to teach.”

– Chris Martin, neurodivergent poet, father, and educator
Thank you!

Be sure to check out Part 2 of this webinar on March 23: Sensory Friendly Strategies for Home, presented by Moira Pena.