Brain & Sensory Processing Differences Across the Lifespan

Dr. Fakhri Shafai, Ph.D., M.Ed.

Presented March 09, 2022

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

Autism & Sensory Processing Differences

- 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

Moira Peña OT
Fakhri Shafai, PhD, MEd

Sensory processing in adults with autism spectrum disorders

autism © 2009
SAGE Publications
and The National
Autistic Society
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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

KEYWORDS
autism; sensory processing; Sensory Profile

↑ **Sensory difficulties across the lifespan**

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

Authors | Authors and affiliations

Jennifer L. Mayer

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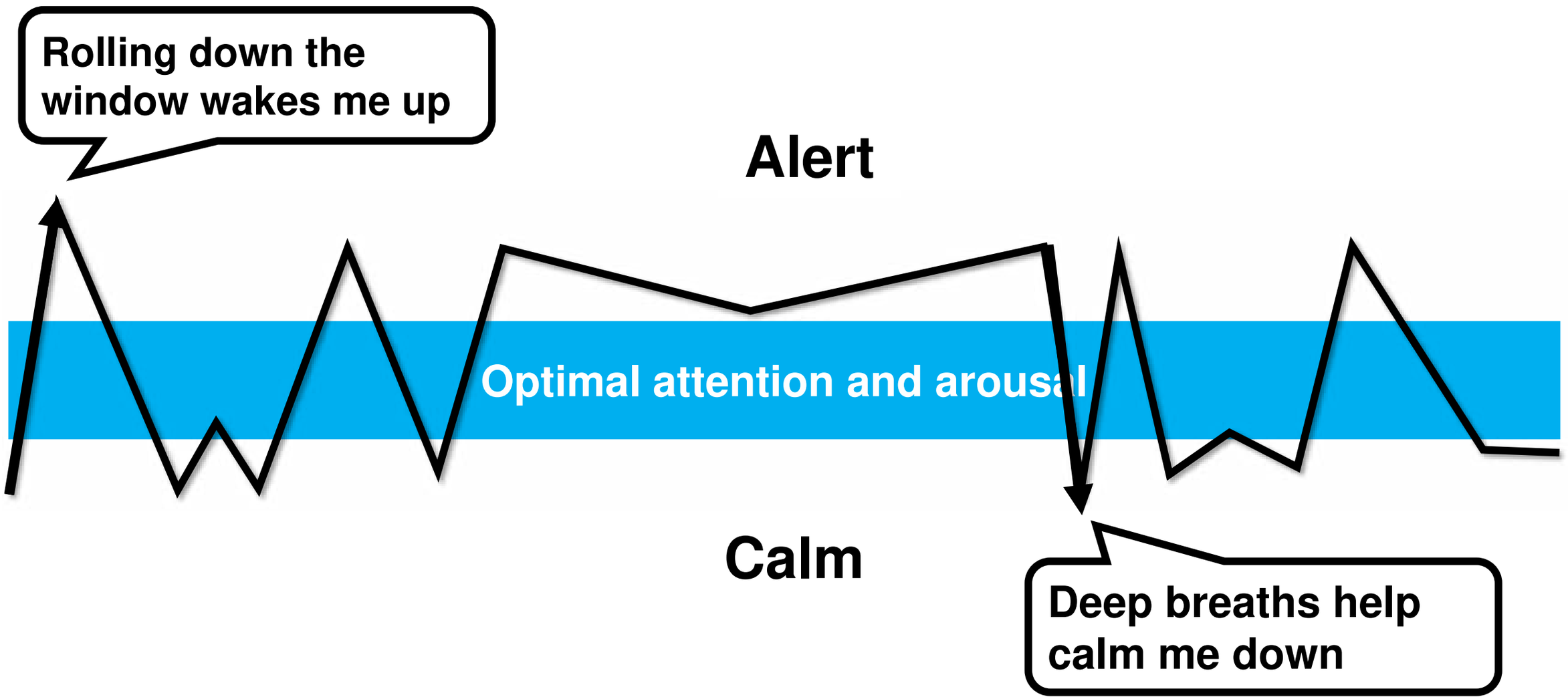
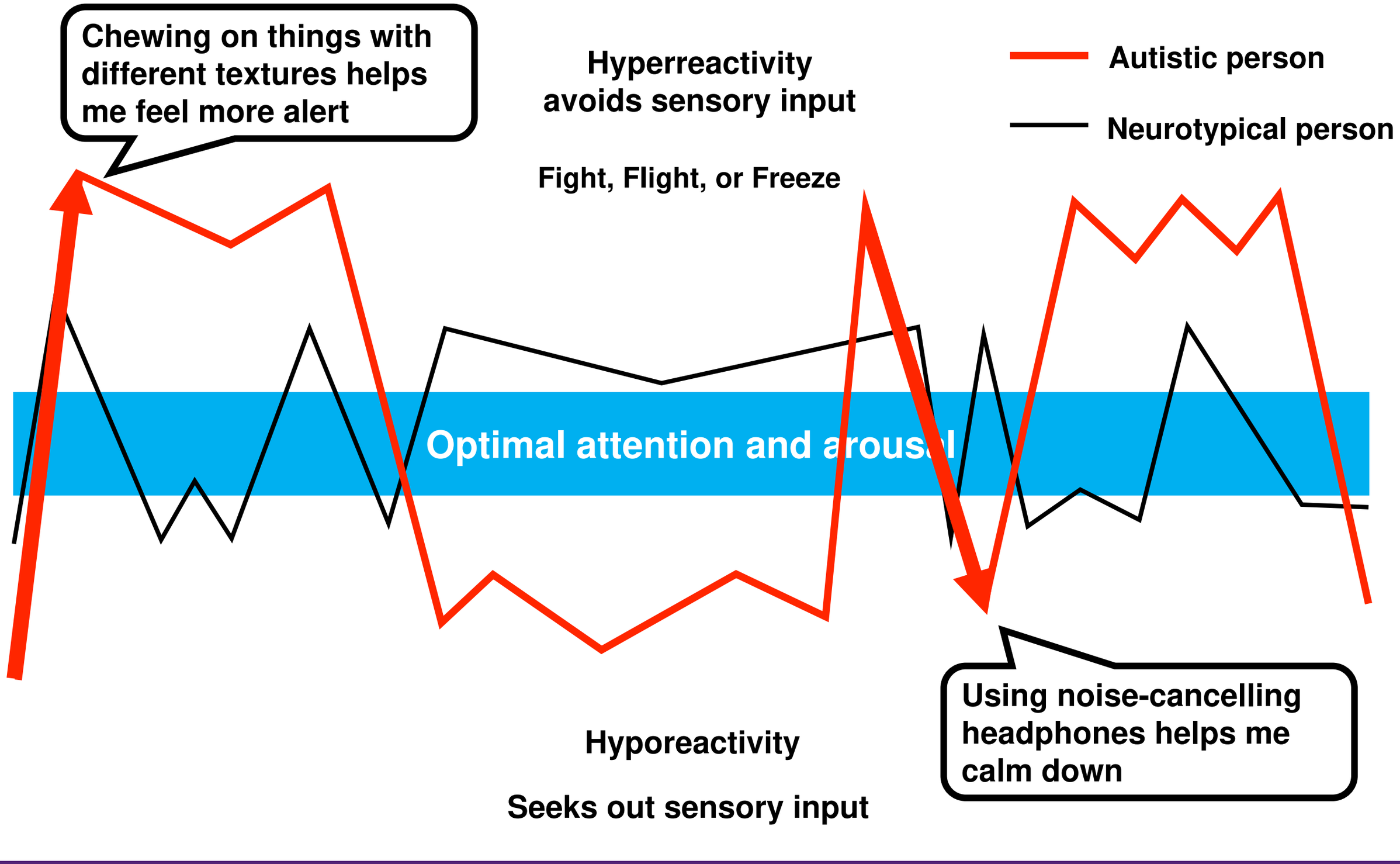
Sensory symptoms **Autism traits**


Rolling down the window wakes me up
Alert
Optimal attention and arousal
Calm
Deep breaths help calm me down


Chewing on things with different textures helps me feel more alert
Hyperreactivity
avoids sensory input
Fight, Flight, or Freeze
Autistic person
Neurotypical person
Optimal attention and arousal
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?

Photo by Olivia Bauso on Unsplash

- **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.)**

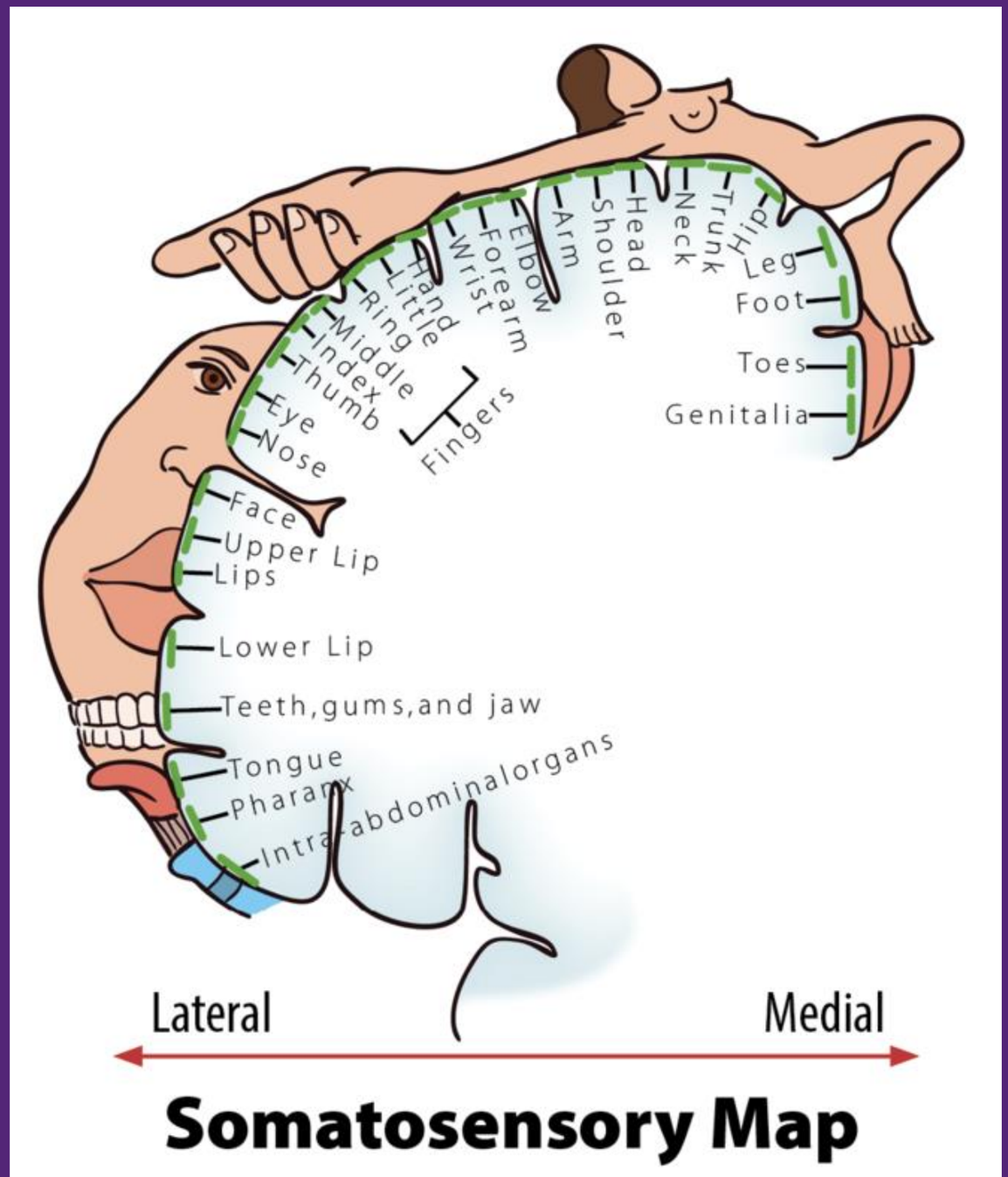
In their own words:

- “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

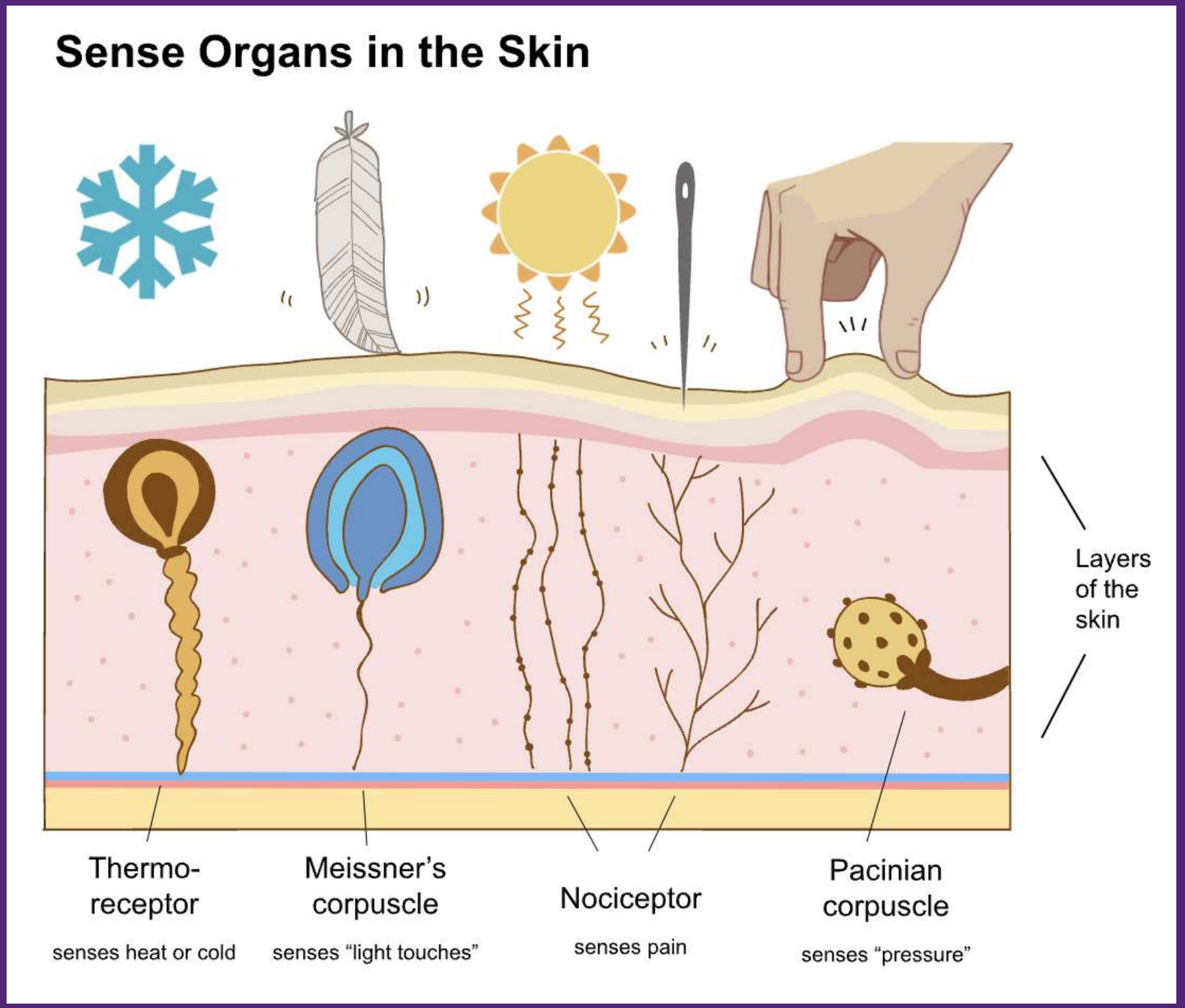


Image taken from AIDE Canada's Sensory Processing Differences Toolkit

Today’s presentation

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Limitations & Future directions

Brain development

- 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

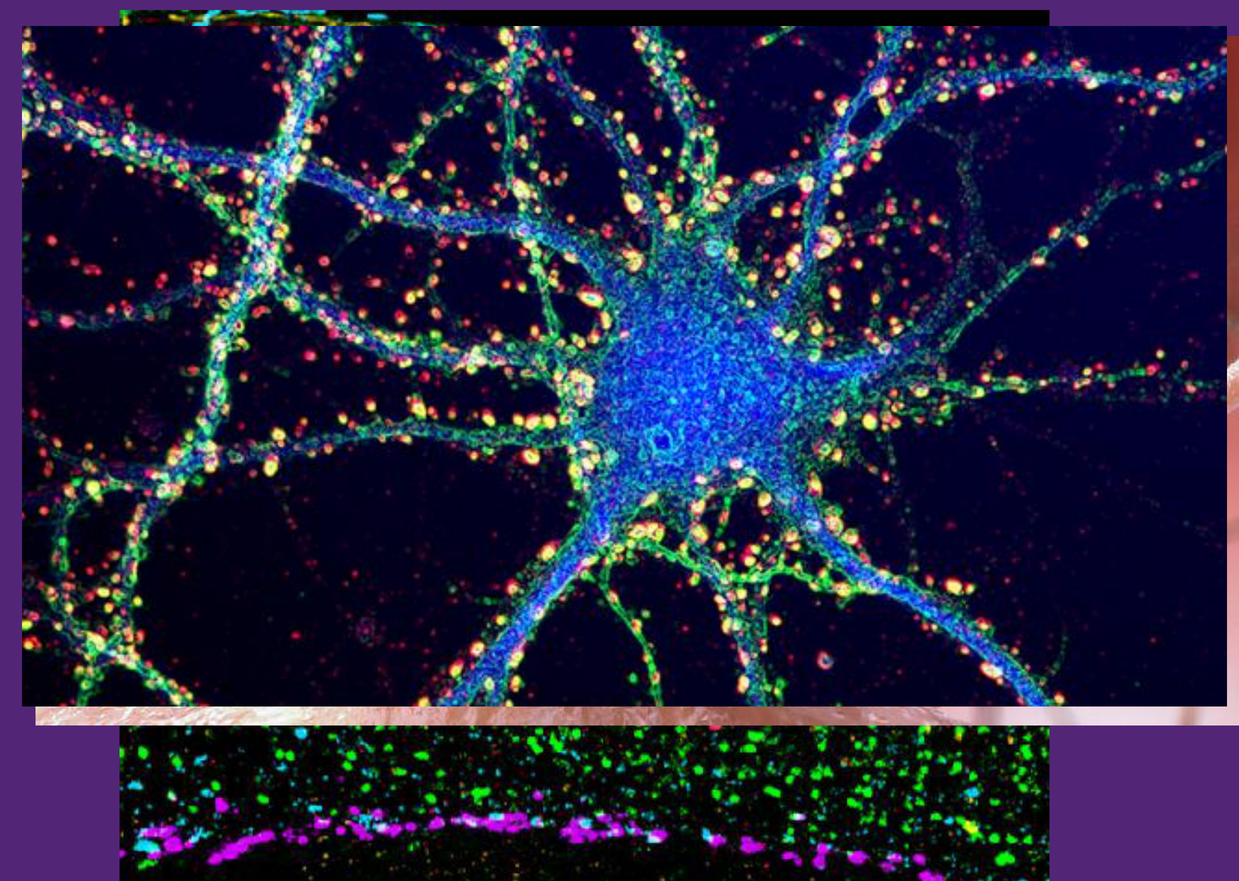


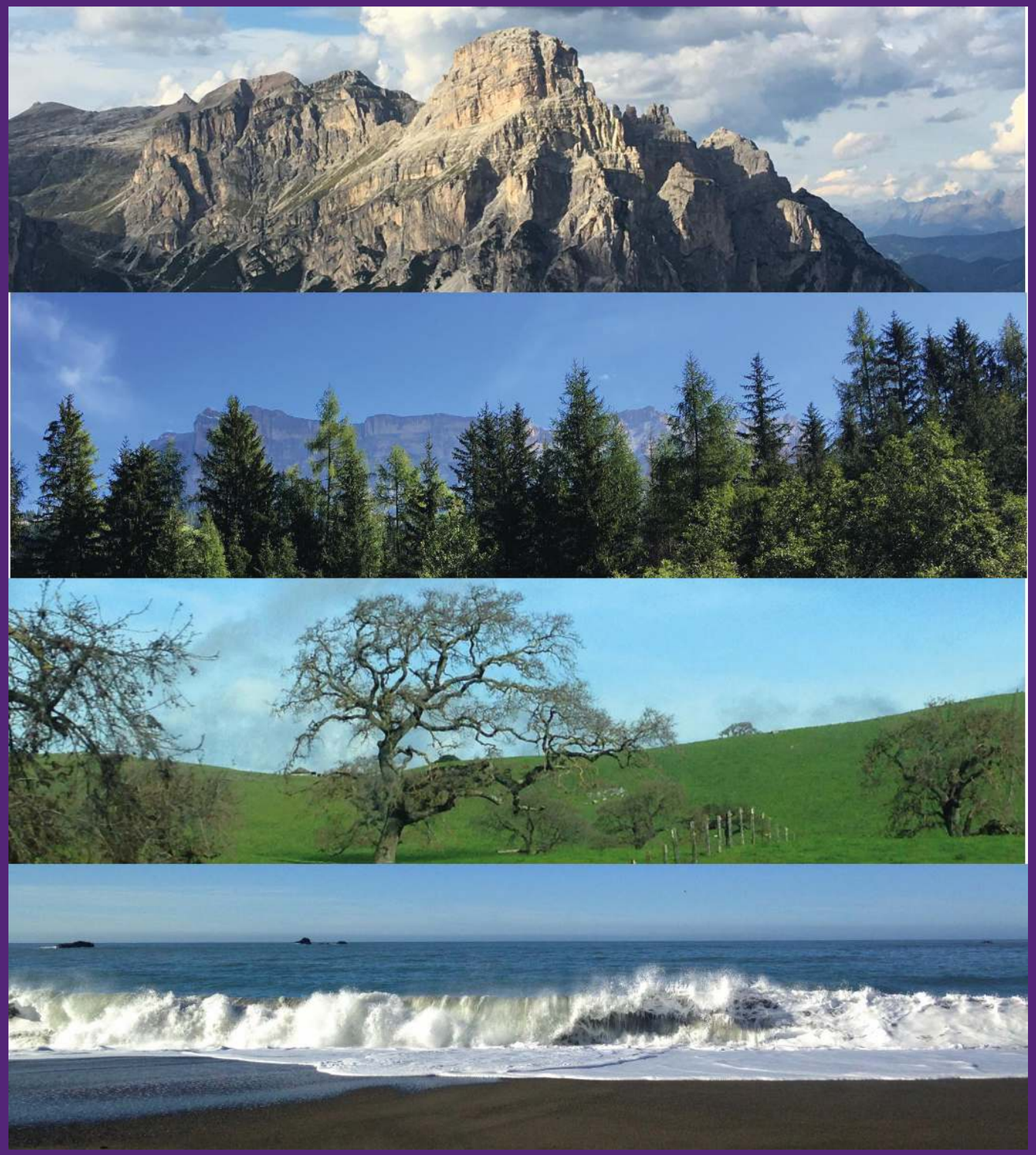
Image taken from Brain Facts/sfn

Image taken from M. P. Boyle, et al. The Journal of Comparative Neurology

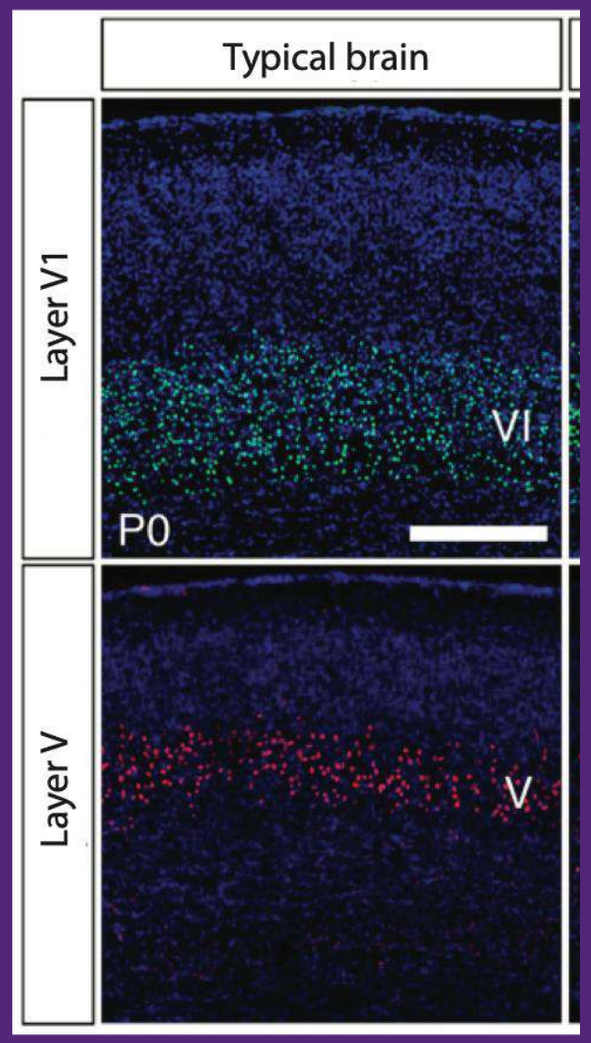
Image take from NIH

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"**

Typical Neuron **ASD Neuron**

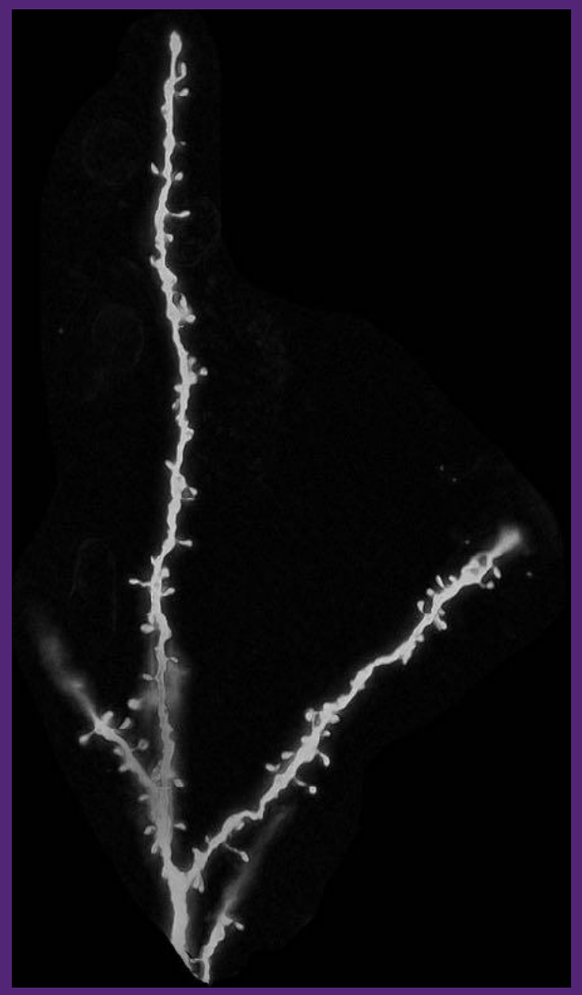


Image taken from Tang et al., 2014

What does this mean?

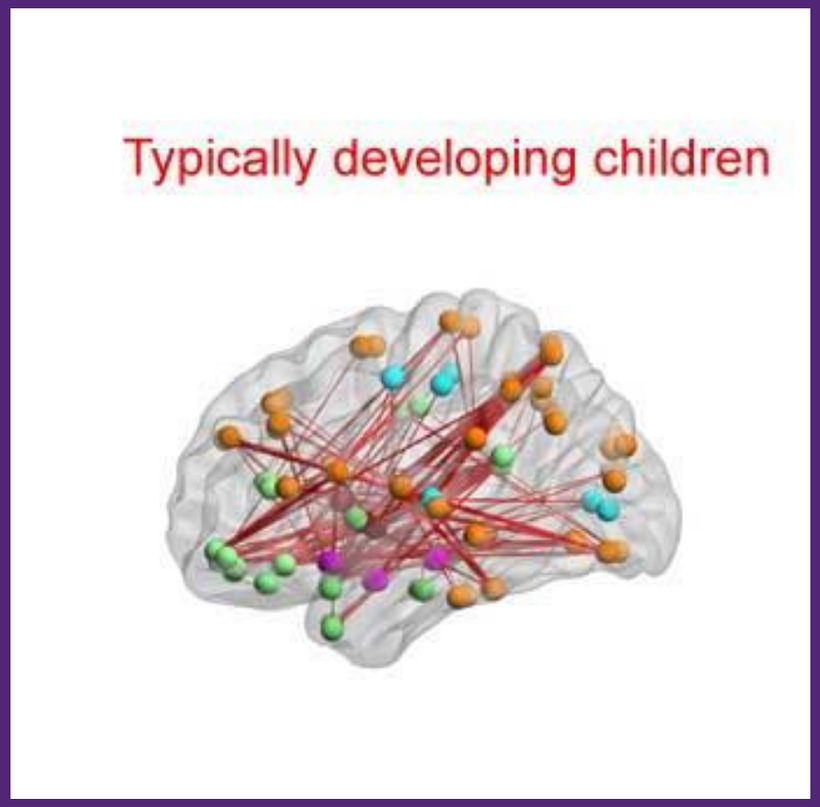
- **Imagine you are in a dense forest**
- **If you go in the same direction over and over, you will eventually create a path**
- **If you take that same path day after day, that path will turn into a trail**
- **With more “traffic” the trail will become a gravel road, then a one-lane street, then a highway, 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)

Neuron image taken from Associated Medical Schools of New York
Photo by Jens Lelie on Unsplash

How do these extra paths lead to sensory issues in ASD?

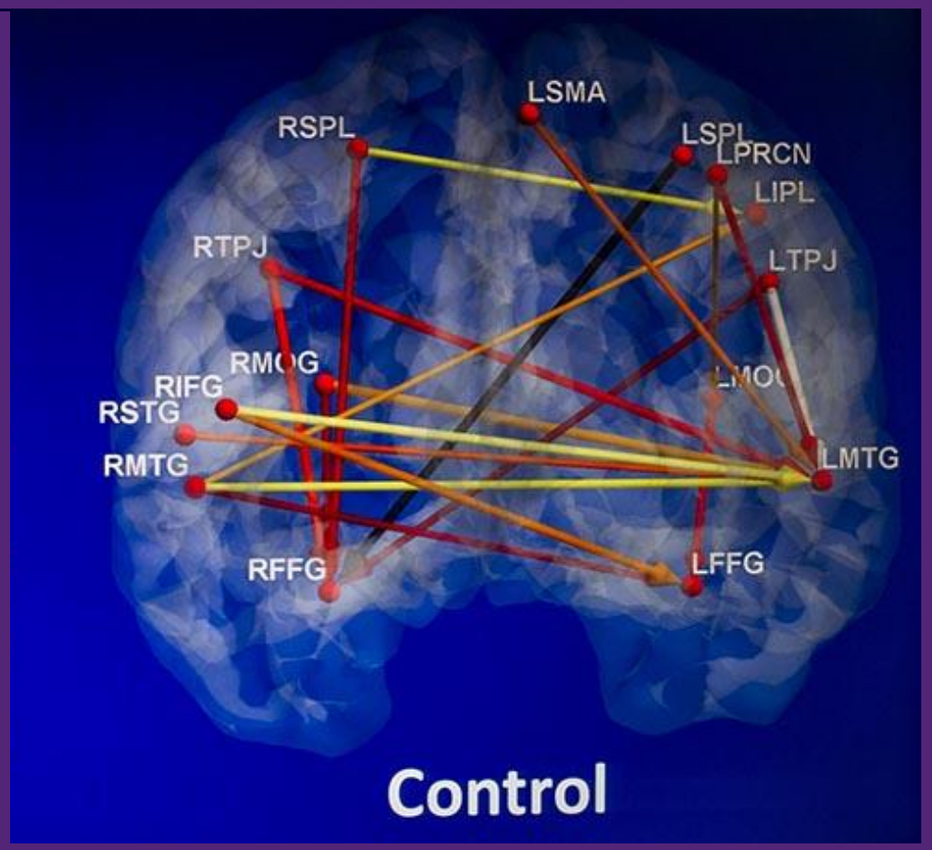


- **In children, we see extra connections in areas close to each other, including sensory areas used for vision, hearing, etc.**

- **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

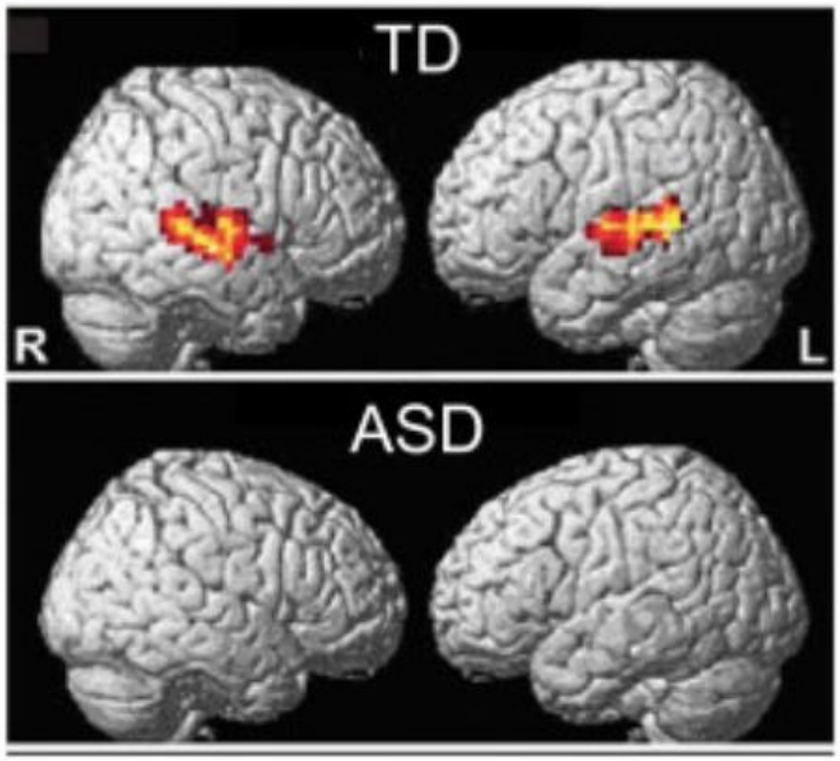
Putting two or more senses together at once = multisensory *integration*

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!**



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

Image taken from Watson & Platt, 2012

Today’s presentation

~~Sensory processing~~

~~Brain development~~

Sensory systems and aging

Limitations & Future directions

Auditory (Hearing) System

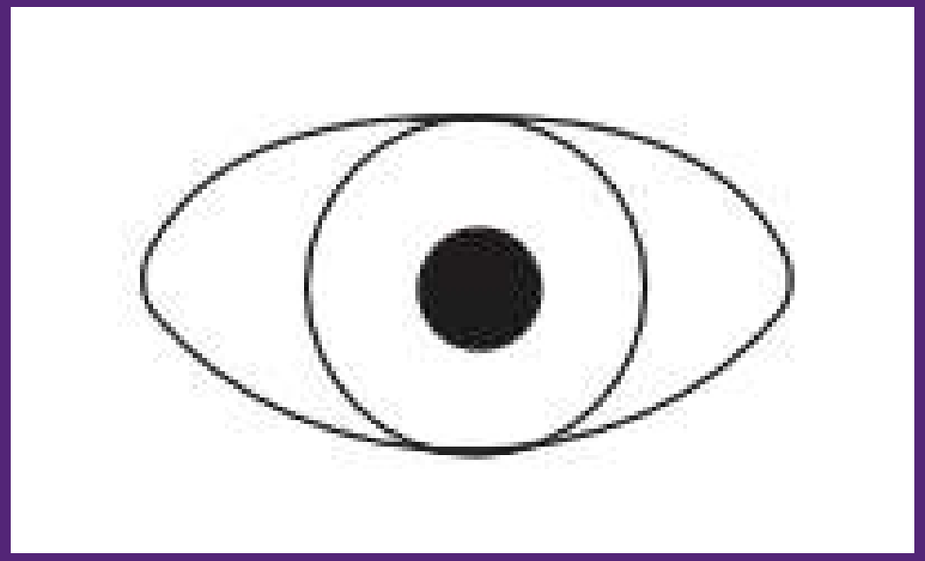
- Matures: 6 months (basics), fine-tuned into late teens, degrades age 40+
- Signs of hyper-reactivity/over-responsivity: avoids certain sounds, startles easily
- Signs of hypo-reactivity/under-responsivity: bangs objects, shouts when speaking

Visual (Sight) System

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

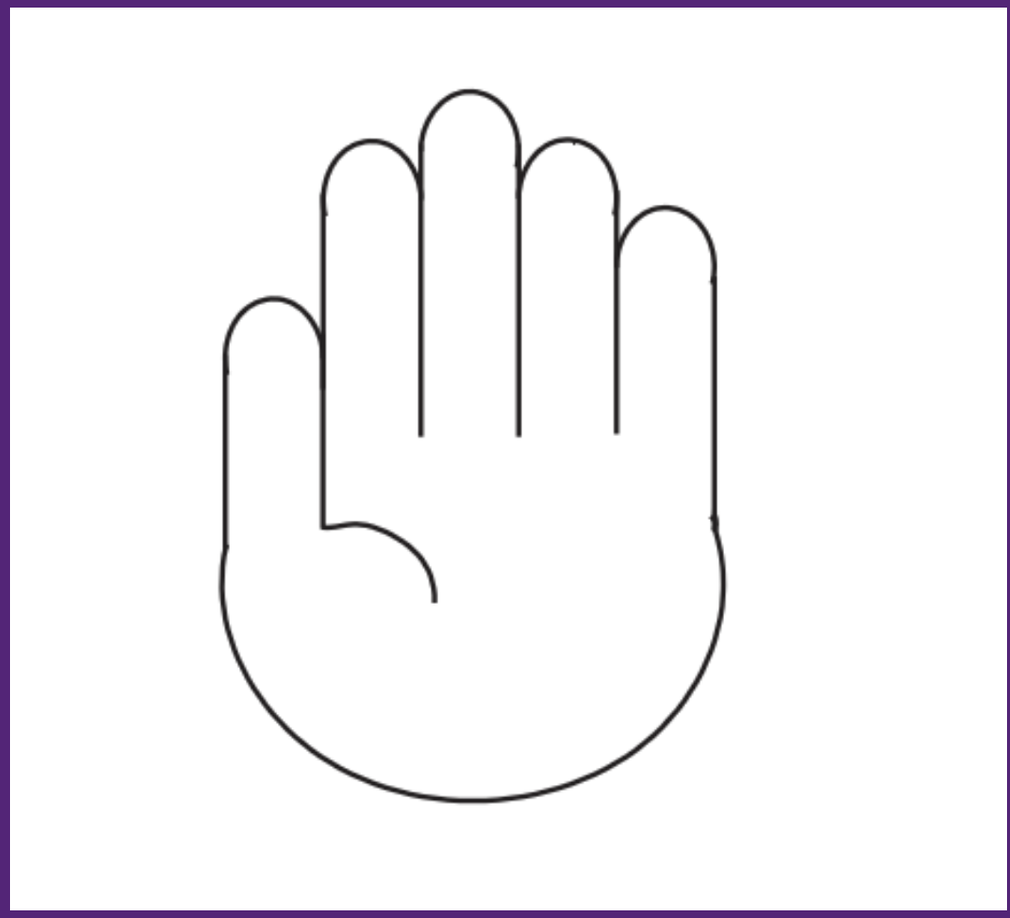
- Signs of hyper-reactivity: frequently covers eyes, covers part of the page when reading

- Signs of hypo-reactivity: difficulty finding objects in crowded environments, waves objects in front of face



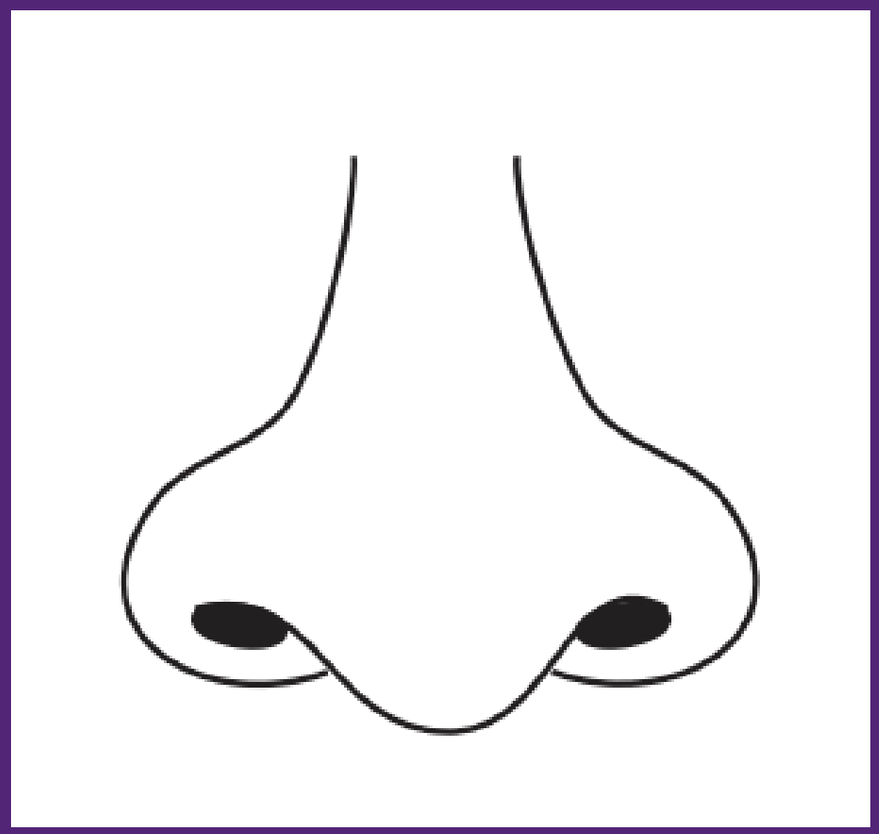
Tactile (Touch) System

- 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

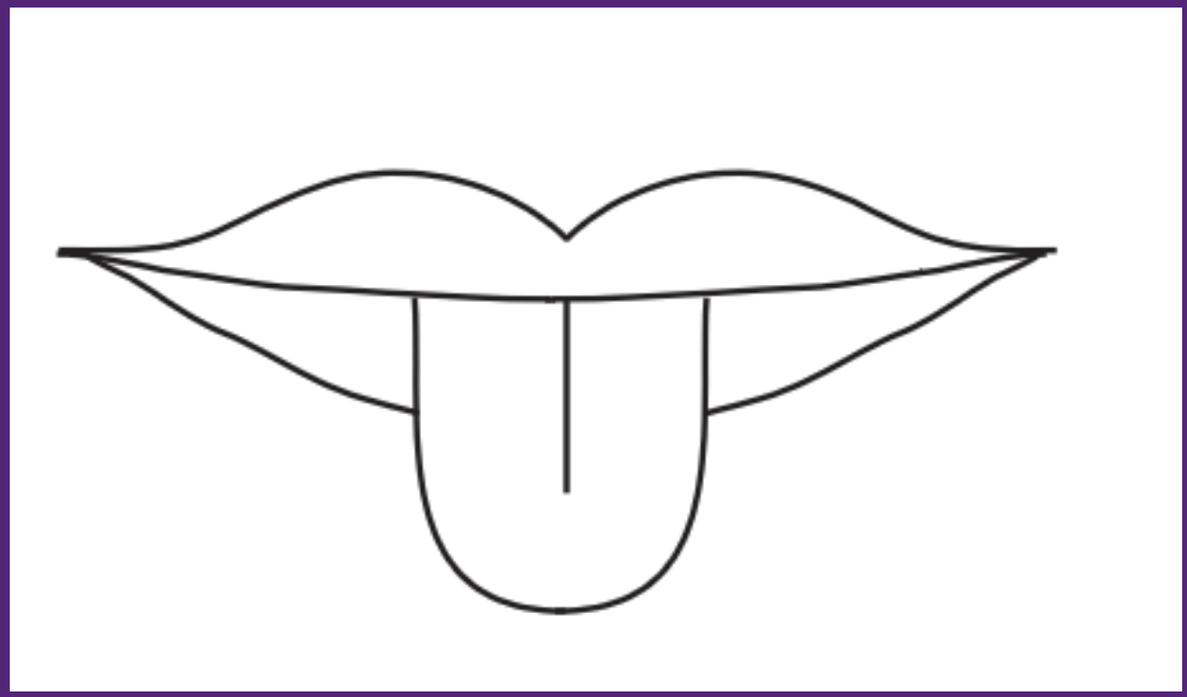


Gustatory (Taste) System

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

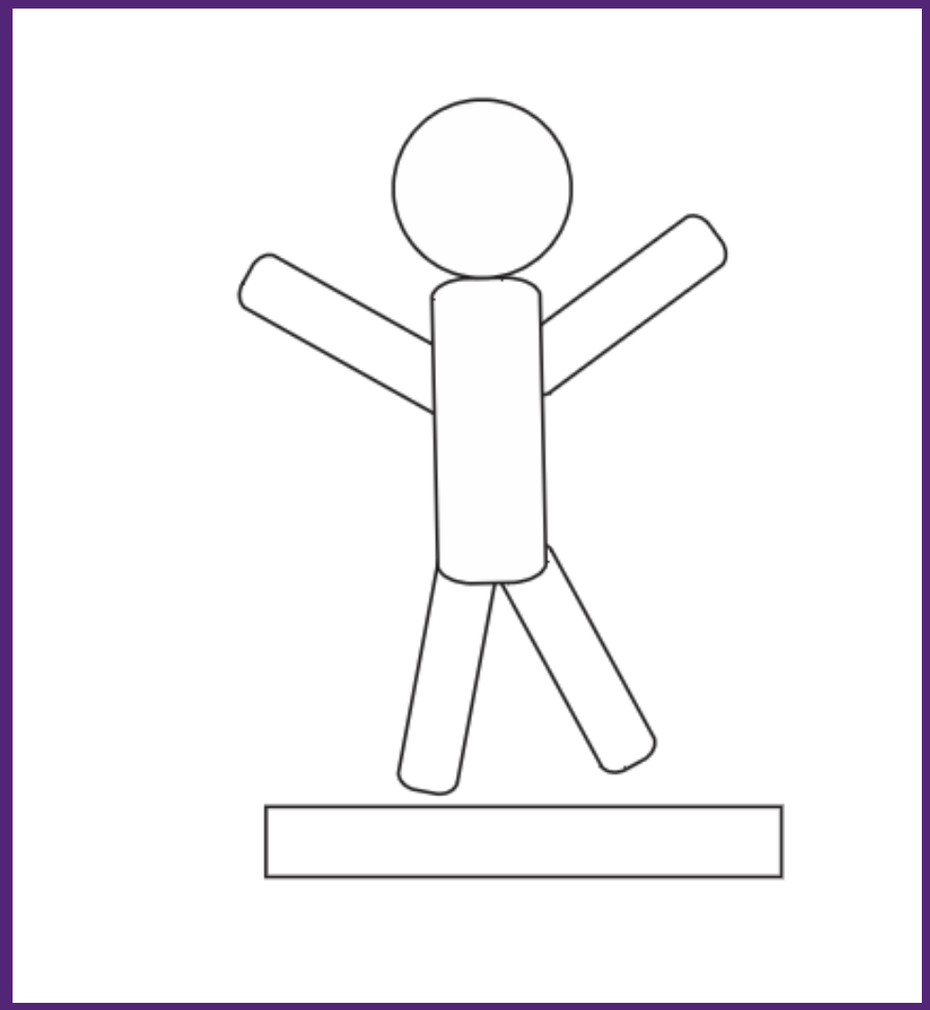
- Signs of hyper-reactivity: very particular about food textures, gags easily

- 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

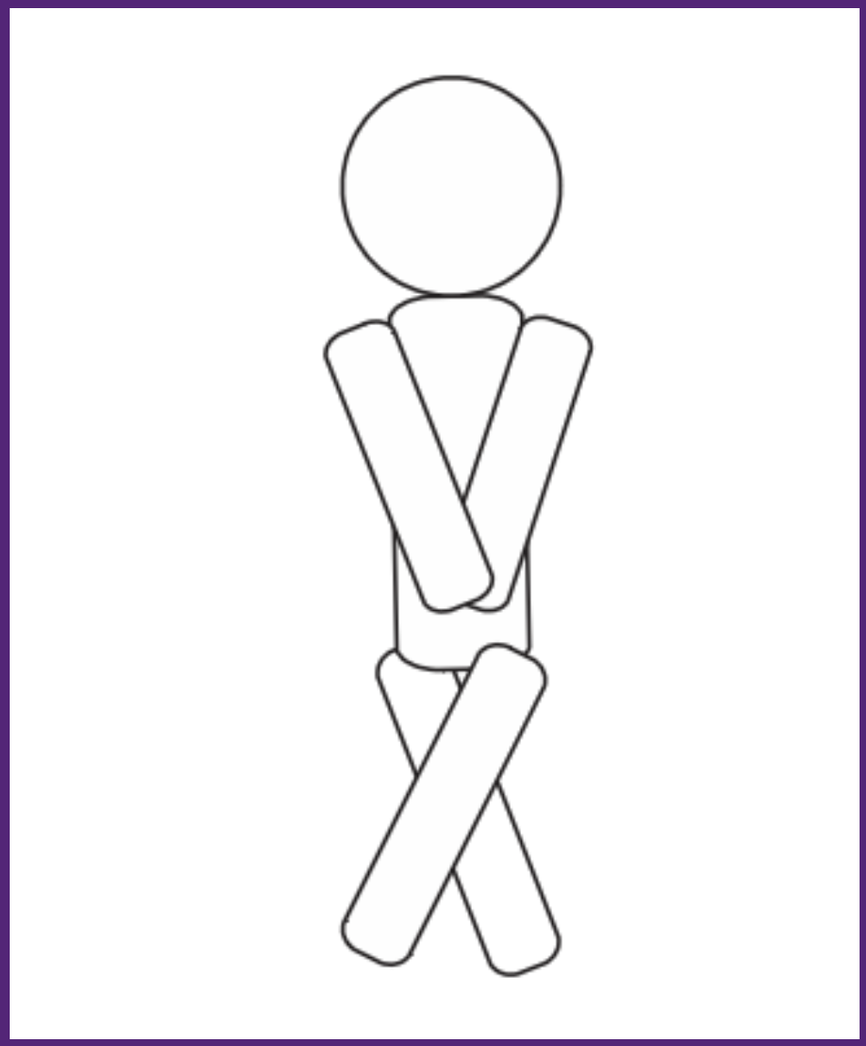
- Matures: 3-4 years old, degrades age 60+
- Signs of hyper-reactivity: Rare
- Signs of hypo-reactivity: Stomps when walking, gives hard ‘high-5s’, hangs on desk for support

Interoception (Internal Body Signals) System

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

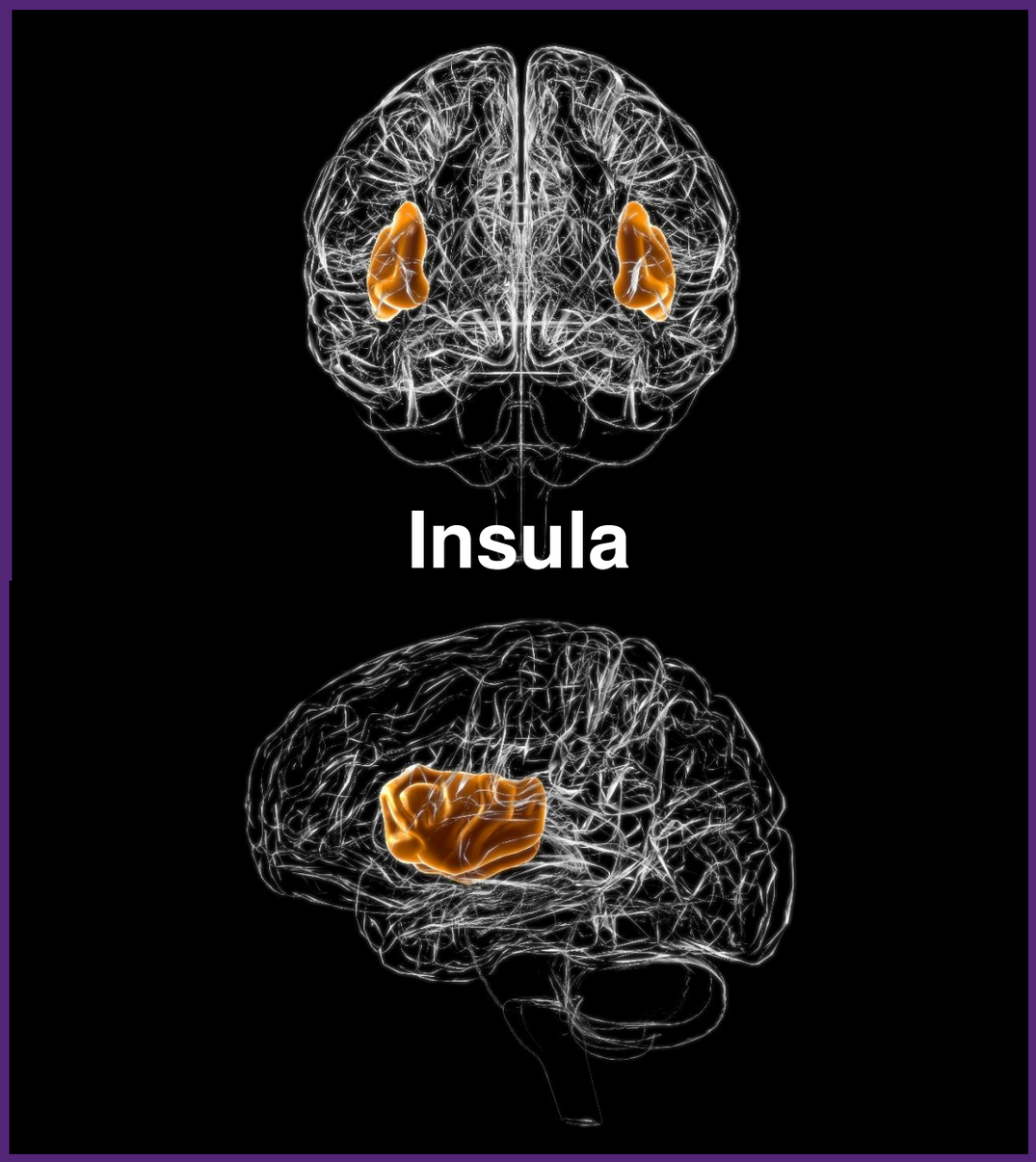
- Signs of hyper-reactivity: Unusually low pain threshold, overly sensitive to temperature changes

- 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

Today’s presentation

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~~Brain development~~

~~Sensory systems and aging~~

Limitations & Future directions

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

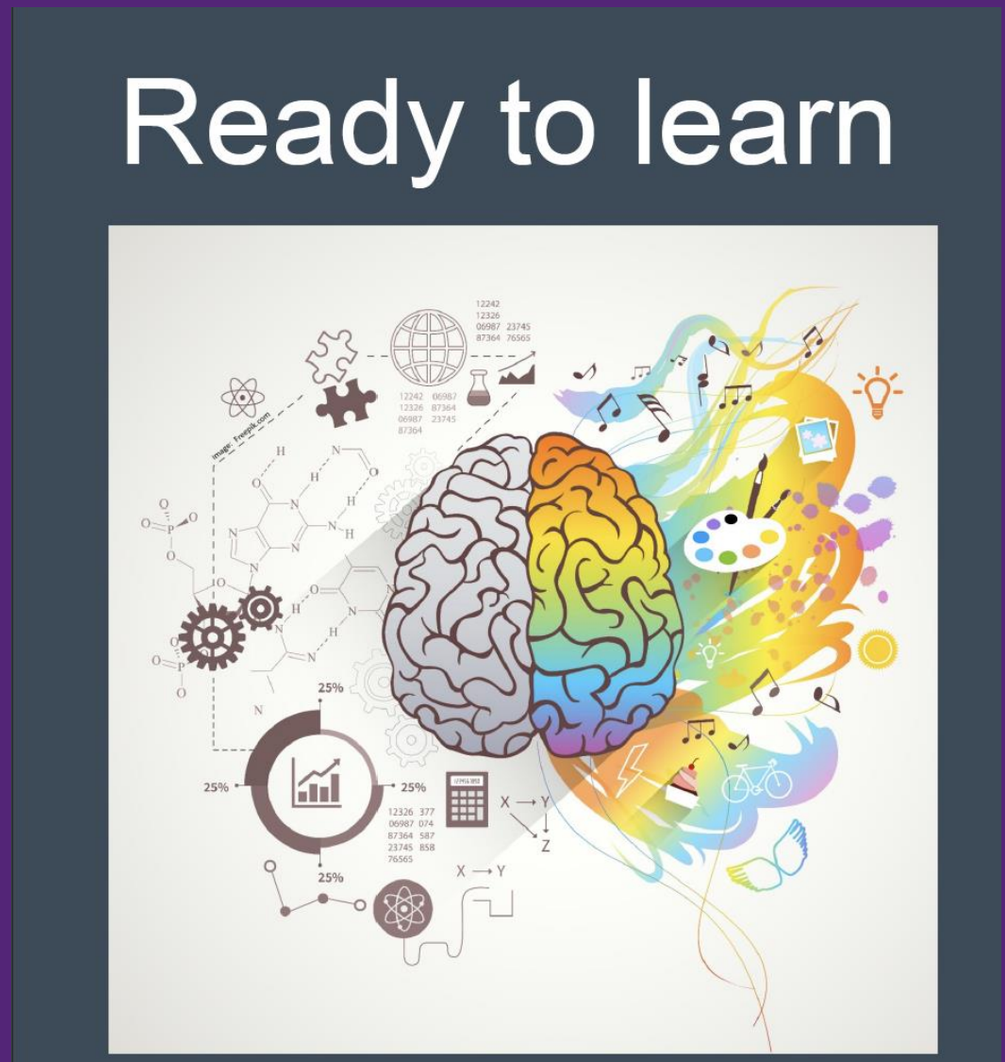
- Utilize technology that allow more autistic individuals to participate in experiments
    - Eye-tracking
    - EGI/EEG
    - Mock MRI scanners
- Design studies in collaboration ar individuals – “Nothing about us, w
    - Family Engagement in Resea University
    - International Society for Autis Collaborator 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)



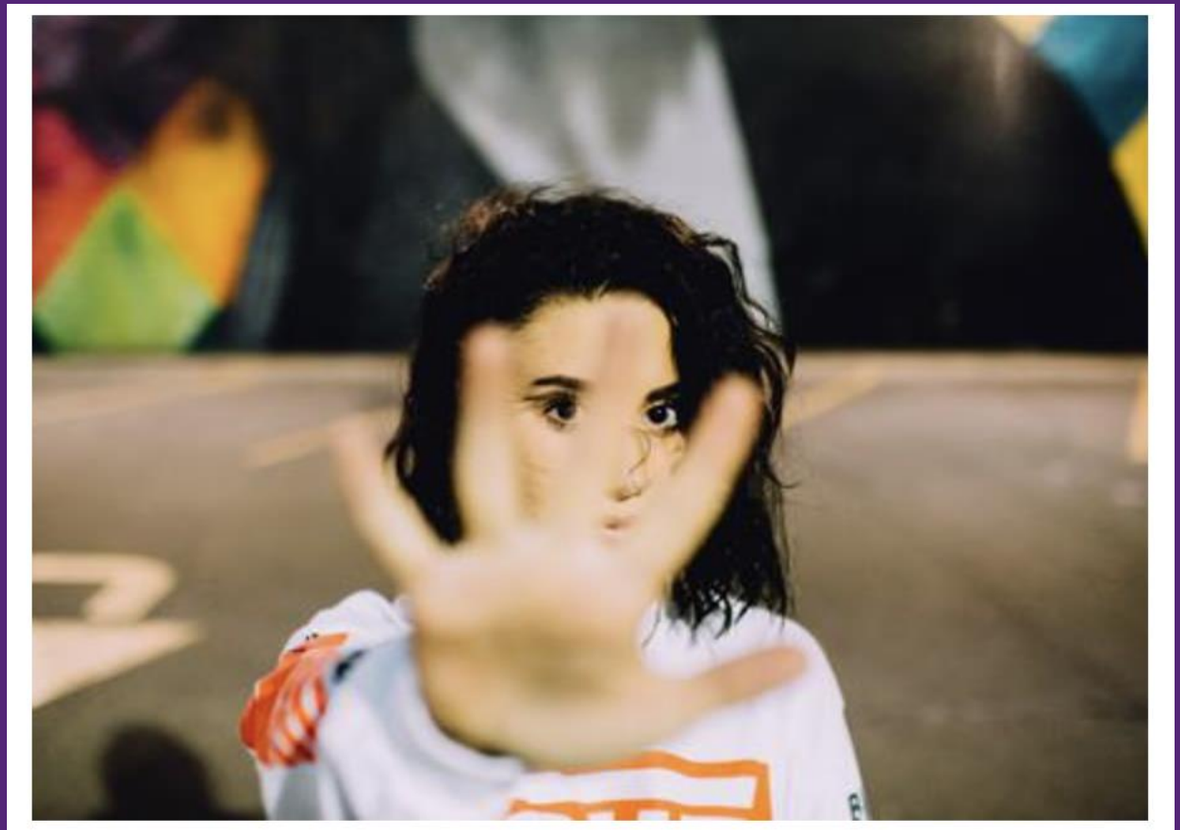
- *Goodall, E. (2016) Interoception 101 Activity Guide, Department for Education, South Australia*
- *Lean, C., Leslie, M., Goodall, E., McCauley, M., and Heays, D. (2019) Interoception 201 Activity Guide, Department for Education, South Australia.*
- *Department for Education Interoception resources*

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

aide canada

Pacific Autism Family Network

Public Health Agency of Canada

Agence de la santé publique du Canada