



# SENSORY PROCESSING DYSFUNCTION

Stephen T. Glass, M.D.  
Northwest Child Neurology  
Woodinville, Washington

PNNS Meeting  
May 14, 2007

# SENSORY PROCESSING DISORDER:

## What's in a name ?

- Nerd, geek.
- Just like his (her?) Dad.
- ADHD, ADD.
- Bipolar Spectrum.
- Non-verbal Learning Disorder.
- Lazy, under-motivated child.
- Lazy, under-motivated parents.
- Generalized Anxiety Disorder.
- Oppositional-Defiant Disorder.
- Childhood Attachment Disorder.
- Sensory Integration Disorder/Dysfunction.
- Developmental Coordination Disorder.

# SENSORY PROCESSING: The Controversy

- Neurobehavioral syndromes have always struggled with nosology.
- Intrinsic resistance to new concepts.
- Relative “merit” of a theory offered by one of “lesser” professional standing...the medical conceit.
- Theory of Sensory Integration originated in Southern California in the 1970s.
- Promise that SI therapy was good for all LD.
- Conceptual paralysis created by a mandate for “evidence-based medicine”.

# SENSORY INTEGRATION: History

- Sensory integration is a theory of brain-behavior relationships.
- Theory developed to explain relationship between:
  - Interpretation of sensory information.
  - Deficits in neuromotor and other areas of performance.
- It is a theoretical construct – we cannot observe CNS processing or sensory integration directly.
- However, one “hard” measurement of output is motor planning (praxis).

# SENSORY PROCESSING/INTEGRATION: Primary Principles

- Sensory Modulation: to selectively attend to salient stimulus, filter and forget others.
- Sensory Regulation: internal strategies to assist in maintenance of one's attention.
- Sensory Discrimination: the development of one's 'body map', awareness of each sensory input, singular then simultaneous.
- Praxis: the ability to perform skilled, non-automatic movements – 'motor planning'.

# SENSORY PROCESSING DISORDER: Clinical Models

- Prematurity / VLBW infant.
- Intrauterine cocaine exposure.
- Social / emotional neglect.
- Physical abuse.
- Colic.
- PANDAS?
- Autistic spectrum disorder.

# SENSORY PROCESSING DISORDER: Selected Clinical Syndromes

- Restless Legs Syndrome.
- Extrapyrarnidal Cerebral Palsy.
- Rett Syndrome.
- Angelman Syndrome.
- Parkinson Disease, Huntington Disease.
- Tourette Syndrome, Obsessive-Compulsive Disorder.
- Post-Traumatic Stress Disorder.



# SENSORY PROCESSING DISORDER: Clinical Associations

- Migraine, cyclic vomiting, motion-sickness.
- Numerous, unexplainable physical symptoms.
- Sleep disorders, parasomnias.
- Syncope, 'breath-holding spells'.
- Allergies, autoimmune disorders.
- Urticaria, dermatographia, 'sensitive skin'.
- Irritable bowel syndrome, food intolerance.
- Frequent urination syndrome.
- 'Fibromyalgia', interstitial cystitis.
- Left handedness.

# SENSORY PROCESSING DISORDER: Biology

- SPD has a likely neurophysiologic origin.
- Physiologic abnormality likely rests in aberrant sensorimotor gating – deficit in **prepulse inhibition**.
- Similar finding in Asperger and Tourette syndrome, OCD.
- Related conditions would suggest intrinsic abnormalities in one of several neurotransmitter functions.
- Varied picture, depending on symptoms but may involve:
  - Hyperserotonemia.
  - Possible dopaminergic excess or receptor site hypersensitivity.
  - Possible selective GABA deficiency.
  - Possible influence of other neuropeptides.
- Familial clustering, parents often demonstrate similar features.
- High concordance rate in twins.

# SENSORY PROCESSING DISORDER: Neuroanatomy

- Macrocephaly is often present (65%)
- Does SPD result from impaired hemispheric differentiation – altered ‘pruning’ ?
- Developmental abnormality in limbic system ?
- Fronto-striatal pathways are vital in sensorimotor gating
- Known conditions with abnormal sensory processing share in common:
  - Reduced grey matter in cerebellum, decreased Purkinje cells
  - Reduced volume of medial prefrontal cortex and cingulum
  - Basal ganglia abnormalities – white matter excess, decreased grey matter volume in ventral thalamus and striatum (L>R)
  - Postulate of disordered fronto-striatal system function

# SENSORY PROCESSING DISORDER: Physiologic Observations

- Increased resting heart rate, increased heart rate variability.
- Ocular signs:
  - Pupillary dilation.
  - ? blue eyes.
  - Photophobia.
- Cutaneous dysautonomia.
  - Cold hands.
  - Increased galvanic skin response.
  - Dermatographia.
  - Urticaria.
  - Flushing, reticulated skin, blush.
- Increased resting muscle tension.
- Tremor.

# SENSORY PROCESSING DISORDER: Physical Findings

- Hypotonia, impaired fine and gross motor control.
- Hypo-/hyperactivity.
- Social maladroitness.
- Variable eye contact.
- Anxiety, hypersensitivity, narrow affective range.
- Macrocephaly.

# SENSORY PROCESSING DISORDER: Motor Deficits

- Hypotonia predominates.
- Impaired motor planning (dyspraxia), poor grading.
- Motor restlessness.
  - Fidgety/hyperactive.
  - Climbing, jumping, other repetitive behaviors.
  - Stereotypies.
- Often have aesthenic body habitus.
- Motor overflow, synkinesis (mirroring), midline problems.
- Oral motor deficits.

## Video please

12 yo graphomotor deficits

5 yo graphomotor, inattention

6 yo gross motor, mannerisms

7 yo synkinesis, 'fixing'

# SENSORY PROCESSING DISORDER: Communication Deficits

- Commonly, poor feeding.
  - Hyper/hyposensitivity.
  - “Messy eater”.
  - Excessive oral exploration, or oral defensiveness.
- May have oral dyspraxia.
  - Decreased phonation and/or articulation.
  - Erratic control of pitch and volume.
  - Dysprosodic speech.
- Associated language deficits.
  - Social/pragmatic deficits.
  - Perseverative language.
  - ? anxiety/attention-based deficits.
  - Selective mutism.



## Video Please

- 4 yo speech apraxia
- 25 yo apraxia, dysphonia, scanning
- 5 yo scanning speech
- 9 yo aphasia, arousal, Asperger

# SENSORY PROCESSING DISORDER: Attention/Arousal

- Often, children are noted to be inattentive.
- Frequently diagnosed as ADHD; even at times ASD.
- In fact, most children are **over-aroused**, or variable arousal seen.
- With over-arousal, often see:
  - Long attention.
  - Perceptive/intuitive.
  - Increased memory.
  - Sensitivity/empathy.
  - Difficult transitions.
  - Inflexibility, rigidity.
  - Frequent volatility.
  - Anxiety.

# Video Please

4 yo increased arousal, stereotypies

# SENSORY PROCESSING DISORDER: Behavioral Deficits

- Frequently, have obsessive behavior.
  - A facet of “long attention”, over-arousal.
  - May “reduce” anxiety.
  - May be avoidant behavior.
  - Learned behavior.
- Reactivity/volatility/anger.
  - Frequently occurs in response to transitions or change.
  - Hence, anxiety-based.
  - Perseveration on emotional response (can't let go).
  - Associated mood disorder.
- Oppositional-defiant disorder (ODD) ?

# SENSORY PROCESSING DISORDER: Social Deficits

- Frequently, misperception of social cues.
- Auditory, tactile and other hypersensitivities.
- Others may demonstrate excessive passivity.
- However, may be controlling in order to avoid imposed change. Treacherous in competitions.
- Inattention, distractibility (too attentive on the wrong thing). Long latency of responses.
- Poor motor skills, reduced grading and coordination.

# SENSORY PROCESSING: Concept of “Sensory Threshold”

- Frequently, colicky babies.
- Persistent hypersensitivity.
  - Auditory.
  - Tactile.
  - Visual-spatial.
  - ? olfactory.
- Development of hyposensitivity.
  - Proprioceptive.
  - Vestibular.
  - Possibly others, tactile or auditory.
- Sensory avoidant – sensory seeking behaviors.
  - Avert eye contact, cover ears.
  - Increased level of activity, climbing.
  - Jumping/concussive movements.
  - Swinging, vestibular stimulation.
  - Stereotypic behaviors.

# Video Please

3 yo 'self-stimulation' - vestibular,  
proprioceptive

# SENSORY PROCESSING DISORDER: Over Arousal

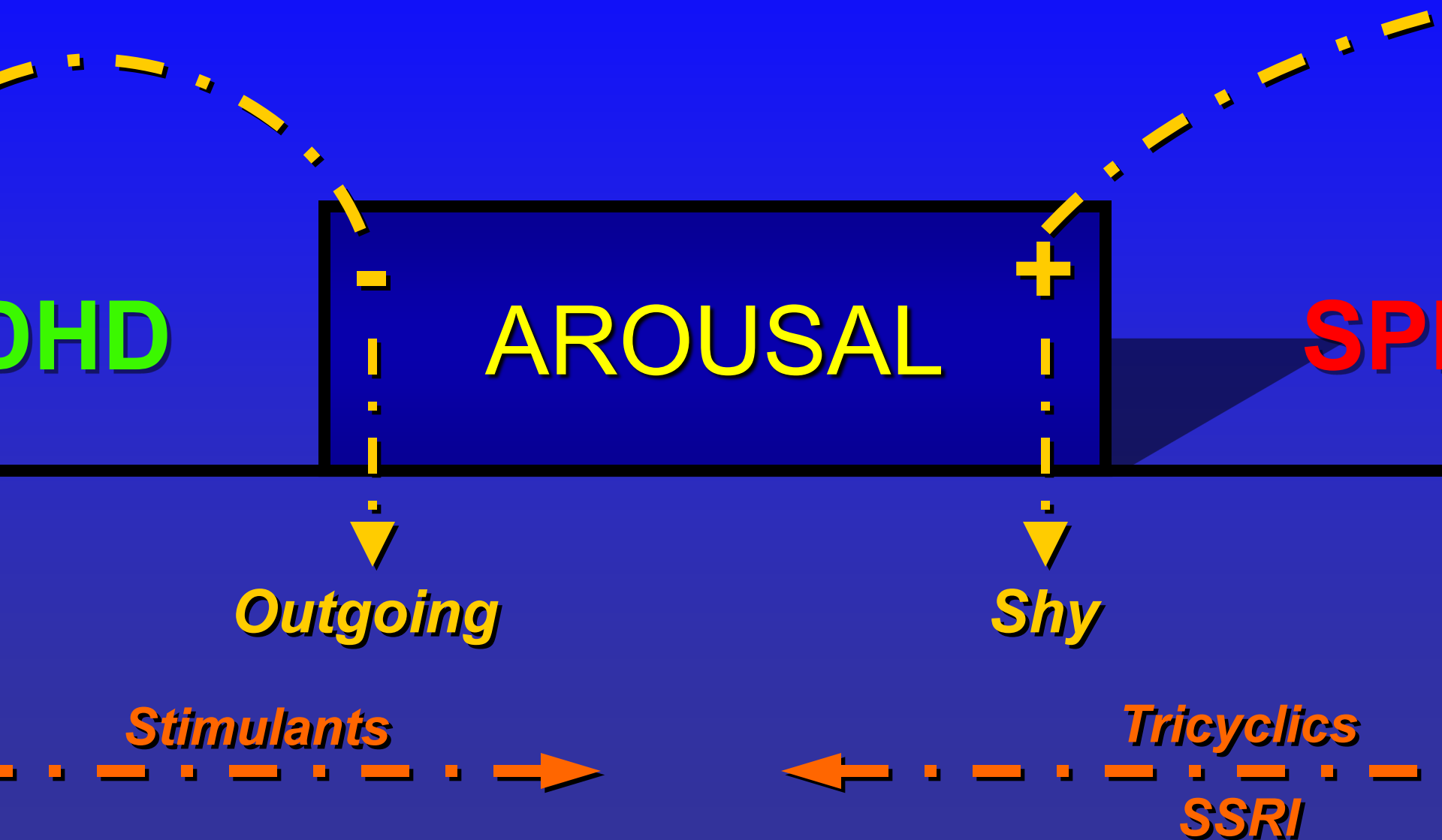
- Children “too aware” of their environment.
- Less able to “filter and forget”.
- Less able to create a conceptual foreground versus background.
- How to prioritize, organize and sequence complex sets of information.
- Children may be inattentive but not for lack of attention, rather, too much attention on the “wrong” stimulus.
- Obsession/perseveration may result.



# Under-arousal (the other end of the spectrum)

- Like a child who is tired, tends to be active, distractible, impulsive.
- Clinical prototype is attention deficit disorder.
- Failure to orient to the proper stimulus, highly distractible, may be overactive, typically impulsive.
- Largely unaware of extrinsic stimuli, fearless.
- Socially uninhibited, outgoing.

# AROUSAL: A CONTINUUM

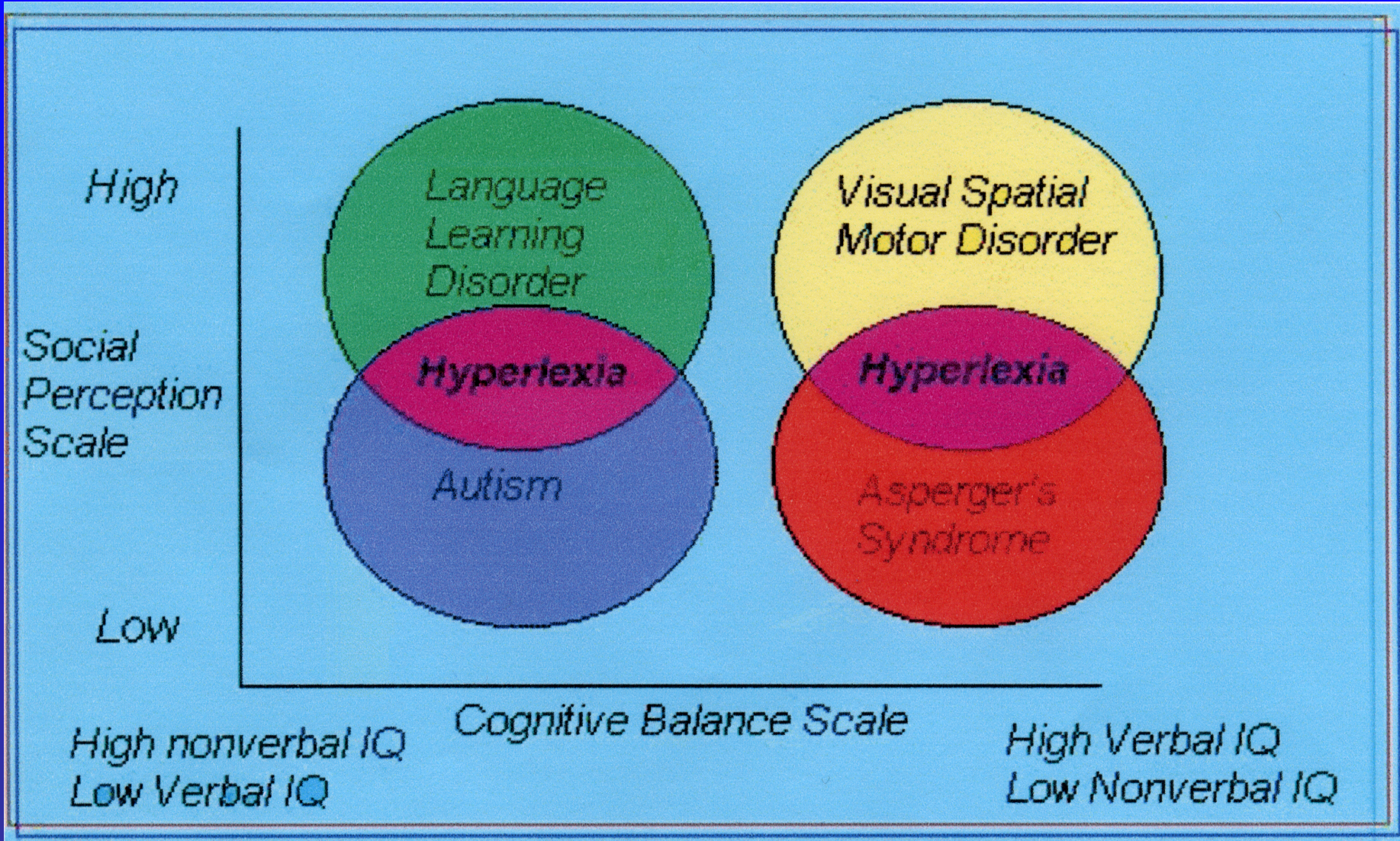


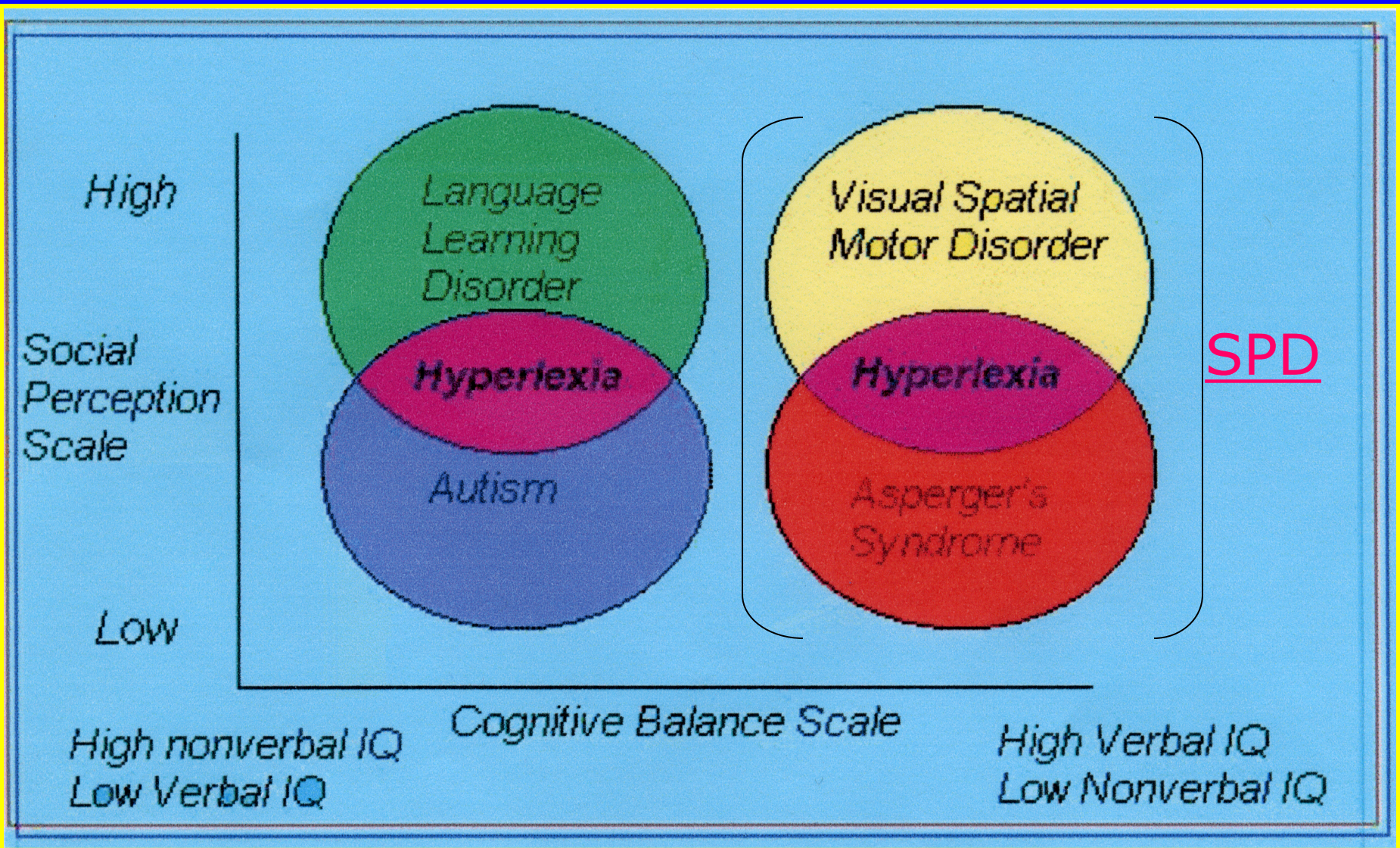
# SENSORY PROCESSING vs. ADHD

- Frequently, confusion in diagnosis.
- Conceptual, seem diametrically opposed.
- However, physiologic symptoms/traits may coexist.
- Several primary differences:
  - ADHD – uninhibited, impulsive, forward.
  - SPD – reticent, withdrawn, anxious and cautious.
- Many aspects of behavioral/environmental support are similar.
- However, differing therapy and medication needs.

# SENSORY PROCESSING: Autism as the Prototype of "Extreme Over Arousal"

- On the arousal spectrum, autistic spectrum disorder is at the "upper end".
- Like SPD, perseverative behavior, anxious, sensory-overwhelmed.
- Highly variable performance based on familiarity or predictability of environment.
- However, ASD involves intersection of a social and a language continuum with the abnormalities in arousal.
- Asperger syndrome and sensory processing disorder, however, are far more similar.





# SENSORY PROCESSING DISORDER: Treatment

- Education/Demystification.
  - A major facet is to simply “explain” the nature, character and behavioral attributes of SPD and why.
  - Serves to acknowledge parents’ observations which have often been misunderstood for years.
  - Gives a conceptual framework within which the family can function and often, “natural” responses occur.
  - May help parents to depart from the notion that “they caused it”.. Rather, emphasis should be on child’s ‘endowment’, acquired prenatally (usually).

# SENSORY PROCESSING DISORDER: Treatment

- Maturation.
  - Over time, slow, steady improvement in most of the developmental attributes.
  - Most of the hypervigilant, shy children will no longer be shy by late adolescence or early young adult years (90%).
  - Despite maturation, the “timetable” of skill acquisition is discordant with peers.
    - Rigid expectations based on age/grade.
    - Increasing intolerance on the part of peers.
    - Sense of “normal” created by their own personal experience.
  - Despite improvement, individual areas of skill attainment cannot be ignored.



# SENSORY PROCESSING DISORDER: Treatment

- Adaptations.
  - Alteration in child's sensory environment to reduce unnecessary exposure.
  - In the school-age child, alteration of written expectations often needed.
  - Alternatives to handwriting could be pursued instead.
  - Social adaptations including explanation to peers?
  - Consistent support for child, as needed, in light of social inadaptability.
  - Explanations can be given to parents as to "why" a given behavior or performance happens.

# SENSORY PROCESSING DISORDER: Treatment

- Behavioral Expectations.
  - Structure, consistency and predictability.
  - Gradual transitions and announced change.
  - Always indicate what is wanted rather than what is not wanted, use words, not emotions, stay non-reactive.
  - Contingent reward systems – token economy.
  - Preferential seating in classroom, sit next to good listeners.
  - Use consistent, cajoling and positive influence. Avoid confrontation, control and “attitude”.

# SENSORY PROCESSING DISORDER: Treatment

- Developmental Individual Difference Relationship Model (DIR) – Greenspan
- Floortime – premise is that children learn skills from the relationships with significant people in their lives – these are largely child-directed sessions building an internal ‘desire’.
- Relationship Development Intervention (RDI) – Gutstein - building social and intellectual competencies by the gradual immersion of a child into an authentic emotional relationship, then fostering motivation and tool-building to foster ‘social intelligence’.
- Collaborative Problem-Solving (CPS) – establish a relationship of mutual trust, learn motives and feelings of the child then offer more adaptive options to facilitate incorporation of newly learned skills into day to day activities and habitual function.

# SENSORY PROCESSING DISORDER: 'SI' Therapy

- A part of the overall treatment program, not the only focus.
- Measurable benefit needed to justify its continuation.
  - A 9-12 month trial?
  - Even after benefit may need to take intermittent “breaks”.
  - In some, might best be combined with other therapy approaches, perceptual motor tasks, ‘natural environment therapy’ – (hippotherapy, aquatic therapy, martial arts, dance, gymnastics)
- Evidence-based support is largely lacking – many studies, poorly controlled, complex variables, what to measure?
- Nevertheless, strong empiric evidence in some, keep open mind...
- Target symptoms might include:
  - Motor planning skills.
  - State regulation.
  - Attention span.
  - Social interaction.
  - “Behavior”.

# SENSORY PROCESSING DISORDER: 'SI' Therapy

- Benefit of therapy may be multifaceted.
  - Improved motor planning skills.
  - Enhance parents' awareness and understanding of behavioral approaches.
  - Provide for the child a tool to "self-regulate".
  - Provide advocacy, support and understanding.
- 'SI' therapy may represent benefit, in part, through ongoing advocacy and support (affect vs. effect) – though true for all therapies.
- The 'past' of SI therapy still haunts its present use and endorsement.
- Practical use still remains, though best combined with other modalities.

# SENSORY PROCESSING DISORDER: Education

- Education of parents as to the nature and extent of problem, origin, etc.
- Education to the child to acknowledge strengths, not just weaknesses.
- Education of teachers for appropriate school support.
- Programs teaching self-regulation/behavioral inhibition.
  - ALERT Program, How Does Your Engine Run?
  - 1-2-3 Magic (Phelan).
  - "Floortime"/Relationship-based therapy
- Teaching children how to play.
- Social skills education, though can these skills be generalized?
- Concept of "difference" rather than "disorder". School and insurance support need a "diagnosis", however.
- There are still the disbelievers: Schools, third party payors, other professionals...
- Can we expand present diagnostic classification schemes?

# SENSORY PROCESSING DISORDER: Medication

- There is no medication for the sensory processing disorders.
- There are medications for individual target symptoms, however.
- Pharmacologic choices based on specific target symptoms.
- Other treatment methods need to be pursued first, when appropriate and possible.
- Above all, avoid side effects.
- Caution with stimulant medications.

# SENSORY PROCESSING DISORDER: Specific Medication Choices

- Heightened arousal, hypersensitivity, increased activity.
  - Imipramine, clonidine, guanfacine.
  - Possible SSRIs.
- Obsessiveness, inflexibility, perseveration, ritualistic behaviors, resistance change.
  - Clomipramine.
  - Escitalopram.
  - Citalopram.
  - Sertaline.
  - Fluoxetine.
- Anxiety, excessive fear, hypersensitivity.
  - Buspirone
  - Escitalopram.
  - Citalopram.
  - Bupropion.



# SENSORY INTEGRATION: Specific Med.

## Choices (cont)

- Irritability, anger, behavioral reactivity, dyscontrol.
  - Carbamazepine.
  - Oxcarbazepine.
  - Sodium valproate.
  - Topiramate.
  - Imipramine, nortriptyline.
  - If severe, risperidone, olanzapine, naltrexone.
- Alteration in attention span/overactivity.
  - Atomoxetine ?
  - **Caution** with stimulant medication, however.
  - If stimulant, short-acting vs. long-acting?
- Stereotypes, compulsive movements, tics.
  - Clonidine, guanfacine.
  - Pimozide, haloperidol.
  - Risperidone.

# SENSORY INTEGRATION: Specific Med.

## Choices (cont)

- Sleep disorders.
  - Melatonin.
  - Imipramine.
  - Clonidine.
- Enuresis.
  - Desmopressin.
  - Imipramine.
- Depression.
  - Behavioral Medicine/Psychiatry evaluation.
  - Imipramine, desipramine, nortriptyline.
  - SSRIs.
  - Sodium valproate, carbamazepine, oxcarbazepine.

# SENSORY INTEGRATION: Final Comments

- In evaluating children, at least be open to the concept of sensory integration.
- Also, concept of SI embraces the autistic spectrum.
- Regardless of the biologic processes involved or our label (sensory integration, sensory processing, etc.), this group of children **does** exist.
- This group of children is not simply a subset of “shy” children nor are they simply an artifact of their obsessive, anxious parent thinking.
- Do not criticize things you don’t know about.

# SENSORY INTEGRATION: Final Comments

- Evidence-based medicine is a road map for chartered territories, it should not ignore uncharted territories or paralyze our thinking.
- Nevertheless, don't believe everything you hear, verify purported facts with individual observations and experience.
- Most science begins with hypothesis and empiricism.
- The group of children with sensory integration dysfunction are plentiful, complex and needy, educationally, socially, behaviorally, cognitively and psychologically.

# SENSORY PROCESSING DISORDER: Bibliography

- Ayres, AJ, *Sensory Integration and Learning Disorders*. WPS Publishing, Los Angeles. (1972).
- Fisher, AG, Murray ,EA, Bundy AC *Sensory Integration, Theory and Practice*. FA Davis, Philadelphia. (1991).
- Ottenbacher, K. 'Sensory Integration Therapy: Affect or Effect?' *Am J Occup Ther*. 36:571-578. (1982).
- Bochner, S, Ayres, AJ 'Sensory Integration and Learning Disorders: A question of Theory and Practice' *Austral J Ment Retard*. 5:41-45. (1978).
- Miller, LJ et. al., 'A randomized controlled pilot study of the effectiveness of OT for children with sensory modulation disorder', *Am J Occup Ther*. 61:228-238. (2007)
- Mangeot, SD, Miller, LJ et. al., Sensory Modulation dysfunction in children with ADHD. *Dev Med Child Neurol*, 43:399-406 (2001)
- Miller, LJ, Fuller, DA, *Sensational Kids*. Putnam, New York (2006)
- Biel, LA, Peske, N, *Raising a Sensory Smart Child*. Penguin, New York (2006).

# Thank You

Stephen T Glass, MD  
17924 140<sup>th</sup> Avenue NE, Suite 200  
Woodinville, WA 98072  
425 424-9200  
[stgmdps@isomedia.com](mailto:stgmdps@isomedia.com)















