

Sensory-Motor Deficits in Children With Developmental Coordination Disorder, Attention Deficit Hyperactivity Disorder & Autistic Disorder

2009

Ben-Sasson, A. Carter, A.S. & Briggs-Gowan, M.J. (2009). Sensory Over-Responsivity in Elementary School: Prevalence and Social-Emotional Correlates *Journal of Abnormal Child Psychology*, 37 (5).

Sensory over-responsivity (SOR) towards tactile and auditory input can impact children's participation in academic and social activities; however the prevalence of SOR behaviors and their relation to social-emotional problems and competence has not been rigorously studied. This study investigated SOR in a representative sample of elementary school-aged children ($n = 925$, 50% boys, ages 7-11 years) who were followed from infancy. Sixteen percent of parents reported that at least four tactile or auditory sensations bothered their children. Being bothered by certain sensations was common while others were relatively rare. Parents of children with versus without elevated SOR in school-age reported higher frequencies of early and co-occurring internalizing, externalizing, and dysregulation problems, and lower levels of concurrent adaptive social behaviors. Early identification of elevated SOR and assessment of concurrent social-emotional status are important to minimize their impact on social adaptive behaviors at school age.

Schoen, S.A. , Miller, L.J., Brett-Green, B.A., & Nielsen, D.M. (2009). Physiological and Behavioral Differences in Sensory Processing: A Comparison of Children with Autism Spectrum Disorder and Sensory Modulation Disorder *Front Integr Neurosci.*; 3: 29. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2776488/>

A high incidence of sensory processing difficulties exists in children with Autism Spectrum Disorder (ASD) and children with Sensory Modulation Disorder (SMD). This is the first study to directly compare and contrast these clinical disorders. Sympathetic nervous system markers of arousal and reactivity were utilized in a laboratory paradigm that administered a series of sensory challenges across five sensory domains. The Short Sensory Profile, a standardized parent-report

measure, provided a measure of sensory-related behaviors. Physiological arousal and sensory reactivity were lower in children with ASD whereas reactivity after each sensory stimulus was higher in SMD, particularly to the first stimulus in each sensory domain. Both clinical groups had significantly more sensory-related behaviors than typically developing children, with contrasting profiles. The ASD group had more taste/smell sensitivity and sensory under-responsivity while the SMD group had more atypical sensory seeking behavior. This study provides preliminary evidence distinguishing sympathetic nervous system functions and sensory-related behaviors in Autism Spectrum Disorder and Sensory Modulation Disorder. Differentiating the physiology and sensory symptoms in clinical groups is essential to the provision of appropriate interventions.

Emmanuelle Jasmin, Mélanie Couture, Patricia McKinley, Greg Reid, Eric Fombonne & Erika Gisel' (2009). Sensori-motor and Daily Living Skills of Preschool Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 39, 231-41.

Sensori-motor development and performance of daily living skills (DLS) remain little explored in children with autism spectrum disorders (ASD). The objective of this study was to determine the impact of sensori-motor skills on the performance of DLS in preschool children with ASD. Thirty-five children, 3-4 years of age, were recruited and assessed with a battery of diagnostic and clinical tests. Children showed atypical sensory responses, very poor motor and DLS. Sensory avoiding, an excessive reaction to sensory stimuli, and fine motor skills were highly correlated with DLS, even when cognitive performance was taken into account. Sensori-motor deficits have an impact on the autonomy of children with ASD and interventions should aim at improving and supporting the development of sensori-motor skills.

Oti, R.S. (2009). Atypical Sensory Behaviors in Young Children with Autism Spectrum Disorders. Dissertation.

Previous research has established that individuals with autism spectrum disorders (ASD) have higher rates of unusual responses to sensory stimuli than the typical population. Differences in these behaviors between children with autism compared to children with other clinical populations have not been as consistent. Research in this area is limited by inconsistencies in definitions of what constitutes sensory behavior, differences in how behaviors are assessed, and how styles of responding are defined (e.g. hyper-responsivity versus sensory sensitivity). The three studies included in this dissertation examined unusual sensory responses in children between the ages of 12 and 36 months

who were at higher risk for having ASD. The first study examined the validity of using the Toddler Sensory Profile Questionnaire (TSP) to measure sensory behaviors in children with ASD by identifying items in the TSP that overlap with autism-specific behaviors and comparing performance on the TSP to other measures of sensory behavior. The goal of the second study was to compare the sensory behaviors of children with ASD to typically developing children and children with nonspectrum developmental disorders. In addition, the effect of individual characteristics, such as NVIQ, age, risk status and diagnosis, was examined. The third study examined the relationship between atypical sensory behavior and impairments in socialization by examining the relationship between scores on the TSP and socialization as measured by the Autism Diagnostic Observation Schedule (ADOS), The Autism Diagnostic Interview-Revised (ADI-R), and the Vineland Adaptive Behavior Interview (VABS). Results support previous research that children with autism have higher rates of unusual sensory responses than typically developing peers. However, caution should be used when interpreting findings from studies that use the TSP as several TSP items were identified as autism-specific behaviors. NVIQ, age, and diagnosis were found to have an effect on sensory behavior, but the effect differed based on the sensory modality or style being addressed. Results of Study 3 indicated a relationship between sensory behaviors and socialization, specifically when socialization is measured by the ADI-R and the VABS. Implications of these findings and limitations of the studies and other research regarding sensory behaviors in children are discussed

Annette V. Joosten, Anita C. Bundy & Stewart L. Einfeld (2009). Intrinsic and Extrinsic Motivation for Stereotypic and Repetitive Behavior *Journal of Autism and Developmental Disorders*, 39, 521-531.

This study provides evidence for intrinsic and extrinsic motivators for stereotypical and repetitive behavior in children with autism and intellectual disability and children with intellectual disability alone. We modified the Motivation Assessment Scale (MAS) (1988b); dividing it into intrinsic and extrinsic measures and adding items to assess anxiety as an intrinsic motivator. Rasch analysis of data from 279 MASs (74 children) revealed that the items formed two unidimensional scales. Anxiety was a more likely intrinsic motivator than sensory seeking for children with dual diagnoses; the reverse was true for children with intellectual disability only. Escape and gaining a tangible object were the most common extrinsic motivators for those with dual diagnoses and attention and escape for children with intellectual disability.

Yu-Han Chen, Jacqui Rodgers & Helen McConachie (2009). Restricted and Repetitive Behaviours, Sensory Processing and Cognitive Style in Children with Autism Spectrum Disorders *Journal of Autism and Developmental Disorders*, 39, 635-42.

Many individuals with autism tend to focus on details. It has been suggested that this cognitive style may underlie the presence of stereotyped routines, repetitive interests and behaviours, and both relate in some way to sensory abnormalities. Twenty-nine children with diagnosis of high functioning autism or Asperger syndrome completed the Embedded Figures Test (EFT), and their parents the Short Sensory Profile and Childhood Routines Inventory. Significant correlations were found between degree of sensory abnormalities and amount of restricted and repetitive behaviours reported. Repetitive behaviours, age and IQ significantly predicted completion time on the EFT. The results suggest a cognitive link between an individual's detail-focused cognitive style and their repetitiveness. No such relationship was found with sensory processing abnormalities, which may arise at a more peripheral level of functioning.

Phoebe P.P. Cheung^a & Andrew M.H. Siu (2009). A comparison of patterns of sensory processing in children with and without developmental disabilities. *Research in Developmental Disabilities*, 30, 6, 1468-1480

This study compared the patterns of sensory processing among children with autism spectrum disorder (ASD), attention deficit and hyperactivity disorder (ADHD), and children without disabilities. Parents reported on the frequency of sensory processing issues by completing the Chinese Sensory Profile (CSP). Children with disabilities (ASD or ADHD) exhibited significantly more sensory processing issues than children without disabilities. The results of GLM and discriminant analyses showed that the CSP effectively differentiated between children with and without developmental disabilities. But it failed to identify major differences in sensory processing issues between children with either ASD or ADHD. Sensory processing issues could be one of many criteria that characterize and differentiate the features of children with different developmental disabilities. Although no significant gender differences in sensory processing issues appeared, age was a significant cofounding factor in evaluating sensory processing. Children without disabilities showed some small decreases in sensory processing issues as they aged from 6 to 12 years old. Children with ASD showed some decrease in sensory processing issues over the span of their childhood, while children with ADHD showed a significant increase

in auditory processing issues as well as small increases in many aspects of sensory processing.

Amy J. Newmeyer^{1†}, Christa Aylward², Rachel Akers³, Keiko Ishikawa⁴, Sandra Grether⁵, Ton deGrauw⁶, Carol Grasha⁵ and Jaye White⁵ (2009). Results of the Sensory Profile in Children with Suspected Childhood Apraxia of Speech Physical & Occupational Therapy in Pediatrics, 29(2), 203-218.

Speech-sound disorders are common in preschool-age children, and are characterized by difficulty in the planning and production of speech sounds and their combination into words and sentences. The objective of this study was to review and compare the results of the *Sensory Profile* ([Dunn, 1999]) in children with a specific type of speech-sound disorder, childhood apraxia of speech (CAS), and to explore the relationship between sensory processing and sound-production deficits. Participants were identified prospectively through an interdisciplinary apraxia clinic at a tertiary care pediatric hospital, and results of the Sensory Profile were compiled and reviewed. Thirty-eight children aged 3 to 10 years with suspected CAS were evaluated from July 2003 to July 2005. The results of the Sensory Profile indicated a difference for these children in several factor clusters when compared to typical peers from the normative population of the Sensory Profile. These findings imply that children with suspected CAS may present with differences in sensory processing in addition to speech impairment. When present, these differences in sensory processing could be addressed with specific therapeutic approaches through occupational therapy or consultation with an occupational therapist.

Chang SH, Yu NY. Characterization of motor control in handwriting difficulties in children with or without developmental coordination disorder. Dev Med Child Neurol.. [Epub ahead of print]

Aim The purpose of this study was to characterize handwriting deficits in children with developmental coordination disorder (DCD) using computerized movement analyses. **Method** Seventy-two children (40 females, 32 males; mean age 7y, SD 7mo; range 6y 2mo to 7y 11mo) with handwriting deficits (33 with DCD, 39 without DCD); and 22 age- and sex-matched children without handwriting deficits were asked to perform handwriting tasks on a digital tablet for the collection of kinematic and kinetic data. Practice times required to achieve automation of movement when writing an unfamiliar character were used to assess the motor learning of handwriting. The children were asked to copy three simple and three complex characters, and the velocity and axial pen force used for corresponding strokes were compared. **Results** The attainment of

automated handwriting was markedly slower in children with handwriting deficits and DCD, who used a faster stroke velocity to write simple characters (1.22 times those without handwriting deficits), but when writing complex characters, their stroke velocity and pen force were lower (0.85 and 0.89 times those without handwriting deficits, respectively). Interpretation By linking the results with neuromotor control theories, it was determined that children with DCD have difficulties performing the open-loop and closed-loop movements required for fluent handwriting.

Glazebrook C, Gonzalez D, Hansen S, Elliott D.(2009). The role of vision for online control of manual aiming movements in persons with autism spectrum disorders. Autism, 13(4):411-33.

Recent studies suggest motor skills are not entirely spared in individuals with an autism spectrum disorder (ASD). Previous reports demonstrated that young adults with ASD were able to land accurately on a target despite increased temporal and spatial variability during their movement. This study explored how a group of adolescents and young adults with an ASD used vision and proprioception to land successfully on one of two targets. Participants performed eye movements and/or manual reaching movements, either with or without vision. Although eye movements were executed in a similar timeframe, participants with ASD took longer to plan and execute manual reaching movements. They also exhibited significantly greater variability during eye and hand movements, but were able to land on the target regardless of the vision condition. **In general, individuals with autism used vision and proprioception. However, they took considerably more time to perform movements that required greater visual-proprioceptive integration.**

Wang TN, Tseng MH, Wilson BN, Hu FC.(2009). Functional performance of children with developmental coordination disorder at home and at school. Dev Med Child Neurol, 51(10), 817-25. Epub 2009 Mar 12.

This study investigated the functional performance of daily activities at home and at school in a population-based sample of children with different degrees of motor coordination impairment and competence. Sixteen children (seven males, nine females; mean age 8 y, SD 9 mo) with developmental coordination

disorder (DCD), 25 with suspected DCD ([sDCD] 17 males, eight females; mean age 7 y 6 mo, SD 8 mo), and 63 children without motor problems (39 males, 24 females; mean age 7 y 9 mo, SD 7 mo) were recruited from public schools (Grades 1-3, age 6 y 4 mo-9 y 10 mo) using the Chinese version of the Developmental Coordination Disorder Questionnaire, the Movement Assessment Battery for Children, and the Bruininks-Oseretsky Test of Motor Proficiency. Functional performance was assessed using the Chinese versions of the Vineland Adaptive Behavior Scales and the School Function Assessment-Chinese version. The functional performance of children with DCD and sDCD was statistically significantly lower than those without DCD ($p's < 0.05$). chi(2) and logistic regression analyses showed significant differences among all groups in the proportion of children scoring at the 'inadequate' adaptive level of home performance ($p's < 0.05$). There were also significant differences among the groups in the proportion of children scoring below the cut-off in school performance ($p's < 0.05$). The findings show the pervasive impact of DCD on children's functional performance in daily activities at home and at school.

Green D, Charman T, Pickles A, Chandler S, Loucas T, Simonoff E, Baird G.(2009). Impairment in movement skills of children with autistic spectrum disorders. Dev Med Child Neurol. 51(4):311-6. Epub 2008 Feb 3.

AIM: We undertook this study to explore the degree of impairment in movement skills in children with autistic spectrum disorders (ASD) and a wide IQ range. **METHOD:** Movement skills were measured using the Movement Assessment Battery for Children (M-ABC) in a large, well defined, population-derived group of children ($n=101$: 89 males, 12 females; mean age 11y 4mo, SD 10mo; range 10y-14y 3mo) with childhood autism and broader ASD and a wide range of IQ scores. Additionally, we tested whether a parent-completed questionnaire, the Developmental Coordination Disorder Questionnaire (DCDQ), was useful in identifying children who met criteria for movement impairments after assessment ($n=97$ with complete M-ABCs and DCDQs). **RESULTS:** Of the children with ASD, 79% had definite movement impairments on the M-ABC; a further 10% had borderline problems. Children with childhood autism were more impaired than children with broader ASD, and children with an IQ less than 70 were more impaired than those with IQ more than 70. This is consistent with the view that movement impairments may arise from a more severe neurological impairment that also contributes to intellectual disability and more severe autism. Movement impairment was not associated with everyday adaptive behaviour once the effect of IQ was controlled for. The DCDQ performed moderately well as a screen for possible motor difficulties. **INTERPRETATION:** Movement impairments are common in children with ASD.

Systematic assessment of movement abilities should be considered a routine investigation.

Klein VC, Gaspardo CM, Martinez FE, Grunau RE, Linhares MB. (2009). Pain and distress reactivity and recovery as early predictors of temperament in toddlers born preterm. Early Hum Dev. 85(9):569-76. Epub 2009 Jun 26.

BACKGROUND: Pain reactivity may reflect underlying mechanisms of constitutional aspects of temperament. **AIM:** To examine whether the neonatal biobehavioral reactivity and recovery responses from pain and distress, as well as the gestational age, the illness severity and the amount of painful procedures undergone the Neonatal Intensive Care Unit (NICU) stay, predict temperament later in toddlerhood, in vulnerable children born preterm. **STUDY DESIGN:** Prospective-longitudinal study. **SUBJECTS:** Twenty-six preterm and very low birth weight infants followed from birth to toddlerhood. **OUTCOME MEASURES:** Illness severity was assessed with the Clinical Risk Index for Babies (CRIB) score. The medical charts were reviewed prospectively for obtaining the amount of pain exposure in NICU. For assessing the behavioral and cardiac reactivity and recovery from pain and distress, the neonates were evaluated during routine blood collection in the NICU in the first 10 days of life. Pain and distress reactivity and recovery was measured using the Neonatal Facial Coding System score, the duration of crying, and the magnitude of average heart rate. At toddlerhood, mothers answered the Early Childhood Behavior Questionnaire. **RESULTS:** Higher biobehavioral reactivity to pain and distress predicted higher temperamental Negative Affect, above and beyond gestational age, illness severity and amount of pain exposure in NICU. However, we did not find a predictive relation between gestational age, CRIB score and number of painful procedures undergone NICU and toddler's temperament. **CONCLUSIONS:** The findings highlight the relevance of the neonatal individual characteristics of reactivity for identifying more vulnerable infants for future problems in biobehavioral regulation.

Fuentes CT, Mostofsky SH, Bastian AJ. (2009). Children with autism show specific handwriting impairments. Neurology. 73(19):1532-7.

BACKGROUND: Handwriting skills, which are crucial for success in school, communication, and building children's self-esteem, have been observed to be poor in individuals with autism. Little information exists on the handwriting of

children with autism, without delineation of specific features that can contribute to impairments. As a result, the specific aspects of handwriting in which individuals with autism demonstrate difficulty remain unknown.

METHODS: A case-control study of handwriting samples from children with and without autism spectrum disorders (ASD) was performed using the Minnesota Handwriting Assessment. Samples were scored on an individual letter basis in 5 categories: legibility, form, alignment, size, and spacing. Subjects were also tested on the Wechsler Intelligence Scale for Children-IV and the Physical and Neurological Examination for Subtle (Motor) Signs. **RESULTS:** We found that children with ASD do indeed show overall worse performance on a handwriting task than do age- and intelligence-matched controls. More specifically, children with ASD show worse quality of forming letters but do not show differences in their ability to correctly size, align, and space their letters. Within the ASD group, motor skills were significantly predictive of handwriting performance, whereas age, gender, IQ, and visuospatial abilities were not. **CONCLUSIONS:** We addressed how different elements of handwriting contribute to impairments observed in children with autism. Our results suggest that training targeting letter formation, in combination with general training of fine motor control, may be the best direction for improving handwriting performance in children with autism.

Pan CY, Tsai CL, Chu CH. (2009). Fundamental Movement Skills in Children Diagnosed with Autism Spectrum Disorders and Attention Deficit Hyperactivity Disorder. J Autism Dev Disord.. [Epub ahead of print]

The purpose of this study was to compare the movement skills of children with autism spectrum disorders (ASD), attention deficit hyperactivity disorder (ADHD), and those without disabilities. Ninety-one children (ASD, n = 28; ADHD, n = 29; control, n = 34), ages 6-10 years, were of average IQ participated. After controlling for age, both ASD and ADHD groups scored significantly lower than controls (p 's < .05) on overall gross motor development as well as locomotor and object control subtests, and the ASD group performed more poorly than the ADHD group (p 's < .01) on both subtests. Of the children with ASD and ADHD, only 16% had clinical levels of impairment. Potential underlying factors are discussed, with suggestions for future research.

Cairney J, Hay JA, Veldhuizen S, Missiuna C, Faught BE. (2009). Developmental coordination disorder, sex, and activity deficit over time: a longitudinal analysis of participation trajectories in children with and without coordination difficulties. *Dev Med Child Neurol*. [Epub ahead of print]

Aim Children with developmental coordination disorder (DCD) are known to participate in active play less than typically developing children. However, it is not known whether the activity deficit between children with and without DCD widens or diminishes over time. **Method** Data were obtained from a large, prospective cohort study of children (baseline n=2278, total n=2470). Motor coordination was assessed for 2083 students using the short form of the Bruininks-Oseretsky Test of Motor Proficiency. Participation in organized and free-play activities was assessed using a participation questionnaire on five occasions over 3 years. Mixed-effects modelling was used to examine differences in participation over time between children with probable DCD (pDCD, n=111, 46 males, 65 females) and their typically developing peers (n=1972, 1016 males, 956 females). The mean age for the whole sample was 9 years 11 months (SD 5mo) at assessment 1, 10 years 5 months (SD 5mo) at assessment 2, 10 years 11 months (SD 5mo) at assessment 3, 11 years 4 months (SD 4mo) at assessment 4, and 11 years 11 months (SD 4mo) at assessment 5. **Results** Children with pDCD reported less participation in organized and free-play activities than their typically developing peers, and these differences persisted over time. Among males, the gap in participation in free-play activities between those with DCD and typically developing children diminished substantially over time; among females, it increased slightly. **Interpretation** DCD is associated with a persistent activity deficit in children. Its effect on participation appears to be particularly serious among females but may diminish with time among males.

Gerrard S, Rugg G. (2009). *Sensory impairments and autism: a re-examination of causal modelling*. J Autism Dev Disord. 39(10),1449-63. Epub 2009 Jun 2.

Sensory impairments are widely reported in autism, but remain largely unexplained by existing models. This article examines Kanner's causal reasoning and identifies unsupported assumptions implicit in later empirical work. Our analysis supports a heterogeneous causal model for autistic characteristics. We

propose that the development of a standardised framework for analysing autistic characteristics would facilitate the identification of sub-groups and the location of biological markers for genetic variation. We also support a neuroconstructivist model proposing that peripheral sensory abnormalities disrupt compilation of complex skills; impact on synaptogenesis, synaptic pruning and myelination; and subsequently manifest themselves as autistic behaviours. This model explains some of the structural and functional brain abnormalities and many of the perceptual, cognitive and attentional features found in autism.

Vieira S, Quercia P, Michel C, Pozzo T, Bonnetblanc F. (2009). Cognitive demands impair postural control in developmental dyslexia: a negative effect that can be compensated. *Neurosci Lett.* 462(2):125-9. Epub 2009 Jul 2.

Children with developmental dyslexia exhibit delayed reading abilities and various sensori-motor deficits. The way these various symptoms interact remain poorly understood. The objective of this study was twofold. First, we aimed to investigate whether postural control was impaired in dyslexic children when cognitive demands are increased. Second, we checked whether this effect could be reduced significantly by a treatment aiming to recalibrate ocular proprioception. Twelve dyslexic and fifteen treated dyslexic children (>3 months of treatment) were compared with twelve non-dyslexic children in two conditions (mean age: 11.6+/-2.1, 12.5+/-1.5 and 10.6+/-1.7 years respectively). In a first condition they maintained balance while fixating a point in front of them. In the second condition the postural task was combined with a silently reading one. Balance was assessed by means of a force plate. Results demonstrated that the mean velocity (i.e. the total length) of the center of pressure (CoP) displacement was increased in the reading task only for the dyslexic group. Interestingly, for the treated children, an inverse tendency was observed: the mean velocity (i.e. the total length) and the surface of the 90% confidence ellipse of the CoP displacement decreased for 13/15 patients and for 12/15 patients respectively, while performing the reading task. Values remained similar to those observed for the control children. Altogether, these results strongly suggest that cognitive demands can impair postural control in developmental dyslexia but this interaction could be normalized. These results sustain the hypothesis of a cerebellar origin for dyslexia.

Marton K. (2009). Imitation of body postures and hand movements in children with specific language impairment. J Exp Child Psychol. 102(1):1-13. Epub 2008 Sep 27.

Within the domain-general theory of language impairment, this study examined body posture and hand movement imitation in children with specific language impairment (SLI) and in their age-matched peers. Participants included 40 children with SLI (5 years 3 months to 6 years 10 months of age) and 40 children with typical language development (5 years 3 months to 6 years 7 months of age). Five tests were used to examine imitation and its underlying cognitive and motor skills such as kinesthesia, working memory, and gross motor coordination. It was hypothesized that children with SLI show a weakness in imitation of body postures and that this deficit is not equally influenced by the underlying cognitive and motor skills. There was a group effect in each cognitive and motor task, but only gross motor coordination proved to be a strong predictor of imitation in children with SLI. In contrast, hand movement imitation was strongly predicted by performance in the Kinesthesia task in typically developing children. Thus, the findings show not only that children with SLI performed more poorly on the imitation tasks than their typically developing peers but also that the groups' performances showed qualitative differences. The results of the current study provide additional support to the view that the weaknesses in children with SLI are not limited to the verbal domain.

Shum SB, Pang MY.(2009). Children with attention deficit hyperactivity disorder have impaired balance function: involvement of somatosensory, visual, and vestibular systems. J Pediatr. 155(2), 245-9. Epub 2009 May 15.

OBJECTIVES: To compare standing balance performance and sensory organization of balance control in children with attention deficit hyperactivity disorder (combined type) (ADHD-C) and typically developing children. **STUDY DESIGN:** School-aged children (n = 43) with ADHD-C and 50 age- and sex-matched typically developing children participated in the study. Sensory organization of standing balance was evaluated using the Sensory Organization Test (SOT). In addition to the composite equilibrium score, somatosensory, vestibular, and visual ratios, which were indicators of the ability of the child to use information from the respective sensory systems to maintain balance, were computed. Multivariate analysis of covariance (MANCOVA) was used to compare the outcome variables between the 2 groups while controlling for physical activity level. **RESULTS:** MANCOVA revealed that children with ADHD-C had significantly lower composite equilibrium scores ($P < .001$) and somatosensory ($P = .029$), vestibular ($P = .037$), and visual ratios ($P = .001$) than control

children, by 10.3%, 2.1%, 15.6%, and 16.0%, respectively. **CONCLUSIONS:** Children with ADHD-C had significant deficits in standing balance performance in all conditions that included a disruption of sensory signals. The visual system tends to be more involved in contributing to the balance deficits in children with ADHD-C than the somatosensory and vestibular systems.

Baron-Cohen S, Ashwin E, Ashwin C, Tavassoli T, Chakrabarti B.(2009). Talent in autism: hyper-systemizing, hyper-attention to detail and sensory hypersensitivity. *Philos Trans R Soc Lond B Biol Sci.* 2009 May 27;364(1522):1377-83.

We argue that hyper-systemizing predisposes individuals to show talent, and review evidence that hyper-systemizing is part of the cognitive style of people with autism spectrum conditions (ASC). We then clarify the hyper-systemizing theory, contrasting it to the weak central coherence (WCC) and executive dysfunction (ED) theories. The ED theory has difficulty explaining the existence of talent in ASC. While both hyper-systemizing and WCC theories postulate excellent attention to detail, by itself excellent attention to detail will not produce talent. By contrast, the hyper-systemizing theory argues that the excellent attention to detail is directed towards detecting 'if p, then q' rules (or [input-operation-output] reasoning). Such law-based pattern recognition systems can produce talent in systemizable domains. Finally, we argue that the excellent attention to detail in ASC is itself a consequence of sensory hypersensitivity. We review an experiment from our laboratory demonstrating sensory hypersensitivity detection thresholds in vision. We conclude that the origins of the association between autism and talent begin at the sensory level, include excellent attention to detail and end with hyper-systemizing.

Rieke, E.F., Anderson, D. (2009). Adolescent/adult sensory profile and obsessive-compulsive disorder. *American Journal of Occupational Therapy* 63 (2), 138 - 145.

We sought to describe how the sensory processing of adults with obsessive-compulsive disorder (OCD) differs from that of the general population within the context of Dunn's (1997) model of sensory processing and to evaluate the discriminant validity of the Adolescent/Adult Sensory Profile (AASP). Using unequal variance t tests, the AASP results of 51 adults with OCD were compared with the means of the AASP standardization study's adult age group. Adults with OCD scored higher than the means of the AASP standardization

study's adult age group on sensory sensitivity and sensation avoiding, consistent with predictions based on the OCD literature. Adults with OCD also scored higher on low registration and lower on sensation seeking. The results provide a preliminary description of how the sensory processing of adults with OCD differs from that of the general population and preliminary support for the AASP's discriminant validity.

Rogers SJ. (2009). What are infant siblings teaching us about autism in infancy? Autism Res. 2(3):125-37.

International research to understand infant patterns of development in autism spectrum disorders (ASDs) has recently focused on a research paradigm involving prospective longitudinal studies of infant siblings of children with autism. Such designs use a comparison group of infant siblings without any familial risks (the low-risk group) to gather longitudinal information about developmental skills across the first 3 years of life, followed by clinical diagnosis of ASD at 36 months. This review focuses on five topics: presence of ASD in the infant sibling groups, patterns and characteristics of motor development, patterns and characteristics of social and emotional development, patterns and characteristics of intentional communication, both verbal and nonverbal, and patterns that mark the onset of behaviors pathognomonic for ASD. Symptoms in all these areas typically begin to be detected during the age period of 12-24 months in infants who will develop autism. Onset of the symptoms occurs at varying ages and in varying patterns, but the pattern of frank loss of skills and marked regression reported from previous retrospective studies in 20-30% of children is seldom reported in these infant sibling prospective studies. **Two surprises involve the very early onset of repetitive and unusual sensory behaviors,** and the lack of predictive symptoms at the age of 6 months. Contrary to current views that autism is a disorder that profoundly affects social development from the earliest months of life, the data from these studies presents a picture of autism as a disorder involving symptoms across multiple domains with a gradual onset that changes both ongoing developmental rate and established behavioral patterns across the first 2-3 years of life.

Andrea Faber Taylor & Frances E. Kuo (2009). Children With Attention Deficits Concentrate Better After Walk in the Park. Journal of Attention Disorders Volume 12 (5), 402-409

Objective: In the general population, attention is reliably enhanced after exposure to certain physical environments,

particularly natural environments. This study examined the impacts of environments on attention in children with ADHD.

Method: In this within subjects design, each participant experienced each of three treatments (environments) in single blind controlled trials. Seventeen children 7 to 12 years old professionally diagnosed with ADHD experienced each of three environments—a city park and two other well-kept urban settings—via individually guided 20-minute walks. Environments were experienced 1 week apart, with randomized assignment to treatment order. After each walk, concentration was measured using Digit Span Backwards. **Results:** Children with ADHD concentrated better after the walk in the park than after the downtown walk ($p = .0229$) or the neighborhood walk ($p = .0072$). Effect sizes were substantial (Cohen's $d = .52$ and $.77$, respectively) and comparable to those reported for recent formulations of methylphenidate. **Conclusion:** Twenty minutes in a park setting was sufficient to elevate attention performance relative to the same amount of time in other settings. These findings indicate that environments can enhance attention not only in the general population but also in ADHD populations. “Doses of nature” might serve as a safe, inexpensive, widely accessible new tool in the tool kit for managing ADHD symptoms.

Kopp S, Beckung E, Gillberg C. (2009). Developmental coordination disorder and other motor control problems in girls with autism spectrum disorder and/or attention-deficit/hyperactivity disorder. Res Dev Disabil.[Epub ahead of print]

Examine the rate, predictors, and effect on daily life skills of developmental coordination disorder (DCD) and other motor control difficulties in school age girls with autism spectrum disorder (ASD) and/or attention-deficit/hyperactivity disorder (ADHD), in preschool age girls with ASD referred to a neuropsychiatric clinic, and in a community sample of school age girls. The girls (131 in total) were examined with standardised test of motor function and parent interviews and questionnaires. The school girls were compared with 57 age- and IQ-matched girls from the community. DCD was diagnosed in 25% of clinic school girls with ASD, in 32% of those with ADHD, and in 80% of the clinic preschool girls with ASD. Parents reported more motor problems in the school age clinic group. Agreement between a brief motor screening test and a full comprehensive motor examination was moderate to good in the clinic group. Young age, autistic symptomatology, and low performance IQ predicted more motor coordination problems. Motor coordination problems were related to lower ability in daily life skills even when the effect of PIQ was controlled for. A large minority of school girls with ASD and/or ADHD, and a majority of

preschool girls with ASD meet full diagnostic criteria for DCD. Their motor problems contribute to reduced activity in daily life even when the effects of IQ have been partialled out.

Martin NC, Piek J, Baynam G, Levy F, Hay D. (2009). An examination of the relationship between movement problems and four common developmental disorders. *Hum Mov Sci.* 2009 Nov 25. [Epub ahead of print]

It has been well recognized since the days of "minimal brain dysfunction" (Clements, 1966) that various developmental disorders have a shared aetiology. Poor motor coordination has been implicated as one of the factors in these relationships. This study examines the different patterns in symptomatology of five developmental disorders, namely developmental coordination disorder (DCD), attention-deficit/hyperactivity disorder (ADHD), reading disorder (RD), oppositional defiant disorder (ODD), and conduct disorder (CD) in order to build on the genetic work from Martin, Levy, Piek, and Hay (2006) and Martin, Piek, and Hay (2006) examining the overlap of these disorders. Latent class analysis was used on questionnaire data from 1304 families from the Australian twin ADHD project (ATAP) to examine the patterns of comorbidity of the five disorders. We confirmed and added detail to the shared symptoms between DCD, ADHD, RD, and ODD, but found no links between CD symptoms and any other disorders. Despite the close link previously identified with ODD and CD, this finding suggests a different aetiology for CD.

Dockstader C, Gaetz W, Cheyne D, Tannock R. (2009). Abnormal neural reactivity to unpredictable sensory events in attention-deficit/hyperactivity disorder. *Biol Psychiatry.* 66(4):376-83. Epub 2009 May 31.

BACKGROUND: Cortical oscillations in the sensorimotor region in the 8-12-Hz range ("mu rhythms") are associated with basic somatosensory and motor processes as well as top-down processes such as learning, attention, expectancy, and inhibition. Recent studies suggest that reactivity of these rhythms to sensory input reflects a link between perception and action and that abnormalities in this reactivity might reflect impairment in perception-to-action mechanisms. Individuals with attention-deficit/hyperactivity disorder (ADHD) are impaired in tasks requiring sensorimotor function, attention,

expectancy, and inhibition, yet their sensorimotor mu responses are unknown. Thus, we investigated mu reactivity in a group of adults with ADHD. **METHODS:** Sixteen adults with ADHD and 16 matched control subjects received median nerve stimulation in predictable patterns (trains of four stimuli followed by 4-sec gap) or unpredictable patterns (randomly presented trains of two, four, or six stimuli followed by 4-sec gap). With magnetoencephalography, we examined the effects of stimulus patterning (predictable, unpredictable) on mu reactivity to somatosensory stimuli. **RESULTS:** Compared with control subjects, the ADHD group showed lower mu reactivity overall and no modulation by unpredictable somatosensory input. By contrast, the control group showed robust mu reactivity to stimuli presented in unpredictable but not predictable patterns. These changes were stronger in the contralateral hemisphere compared with the ADHD group. **CONCLUSIONS:** Cortical mu rhythms are modulated by stimulus predictability and might be involved in attentional alerting (awareness of when an unexpected stimulus occurs). Diminished mu modulation in adult ADHD suggests a possible underlying deficit in the perception-to-action system.

Dowell LR, Mahone EM, Mostofsky SH. (2009). Associations of postural knowledge and basic motor skill with dyspraxia in autism: implication for abnormalities in distributed connectivity and motor learning. *Neuropsychology*. 2009 Sep;23(5):563-70.

Children with autism often have difficulty performing skilled movements. Praxis performance requires basic motor skill, knowledge of representations of the movement (mediated by parietal regions), and transcoding of these representations into movement plans (mediated by premotor circuits). The goals of this study were (a) to determine whether dyspraxia in autism is associated with impaired representational ("postural") knowledge and (b) to examine the contributions of postural knowledge and basic motor skill to dyspraxia in autism. Thirty-seven children with autism spectrum disorder (ASD) and 50 typically developing (TD) children, ages 8-13, completed (a) an examination of basic motor skills, (b) a postural knowledge test assessing praxis discrimination, and (c) a praxis examination. Children with ASD showed worse basic motor skill and postural knowledge than did controls. The ASD group continued to show significantly poorer praxis than did controls after accounting for age, IQ, basic motor skill, and postural knowledge. Dyspraxia in autism appears to be associated with impaired formation of spatial representations, as well as transcoding and execution. Distributed abnormality across parietal, premotor, and motor circuitry, as well as anomalous connectivity, may be implicated.

Newmeyer AJ, Aylward C, Akers R, Ishikawa K, Grether S, deGrauw T, Grasha C, White J. (2009). Results of the Sensory Profile in children with suspected childhood apraxia of speech. *Phys Occup Ther Pediatr.* 29(2):205-20.

Speech-sound disorders are common in preschool-age children, and are characterized by difficulty in the planning and production of speech sounds and their combination into words and sentences. The objective of this study was to review and compare the results of the Sensory Profile (Dunn, 1999) in children with a specific type of speech-sound disorder, childhood apraxia of speech (CAS), and to explore the relationship between sensory processing and sound-production deficits. Participants were identified prospectively through an interdisciplinary apraxia clinic at a tertiary care pediatric hospital, and results of the Sensory Profile were compiled and reviewed. Thirty-eight children aged 3 to 10 years with suspected CAS were evaluated from July 2003 to July 2005. The results of the Sensory Profile indicated a difference for these children in several factor clusters when compared to typical peers from the normative population of the Sensory Profile. These findings imply that children with suspected CAS may present with differences in sensory processing in addition to speech impairment. When present, these differences in sensory processing could be addressed with specific therapeutic approaches through occupational therapy or consultation with an occupational therapist.

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Emck C, Bosscher R, Beek P, Doreleijers T. (2009). Gross motor performance and self-perceived motor competence in children with emotional, behavioural, and pervasive developmental disorders: a review. Dev Med Child Neurol. 2009 Jul;51(7):501-17.

AIMS: Motor performance and self-perceived motor competence have a great impact on the psychosocial development of children in general. In this review, empirical studies of gross motor performance and self-perception of motor competence in children with emotional (depression and anxiety), behavioural, and pervasive developmental disorders are scrutinized, with the objective of identifying specific motor characteristics that may be relevant to clinical practice. **METHOD:** A systematic search of studies published between 1997 and 2007 was performed using nine search engines. **RESULTS:** Children in all three categories (emotional, behavioural, and pervasive developmental disorders) exhibit poor gross motor performance and problematic self-perception of motor competence, with certain indications of disorder-specific characteristics. In particular, children with emotional disorders have balance problems and self-perceived motor incompetence; children with behavioural disorders show poor ball skills and tend to overestimate their motor performance; children with pervasive developmental disorders demonstrate poor gross motor performance and self-perceived motor incompetence. As a result, children with developmental and emotional disorders are restricted in participating in games and play, which may lead to inactive lifestyles and further disruption of their psychosocial and physical development. **INTERPRETATION:** Motor problems need more, to some extent disorder-specific, attention in clinical practice than has been provided to date.

Prior to 2009

S. Parush, H. Sohmer , A. Steinberg, M. Kaitz (2007). Somatosensory function in boys with ADHD and tactile defensiveness. *Physiology & Behavior* 90 , 553-558.

In this study, we tested for deficits in somatosensory function in boys with Attention Deficit Hyperactivity Disorder (ADHD) and tactile defensiveness (TD). The subjects were 67 boys with ADHD, sub-typed as TD (ADHD+TD+) or non TD (ADHD+TD-), matched with 60 “typical” children in the control group. Sixty nine percent of the boys with ADHD were categorized as TD. The groups were compared on three measures: (a) performance scores on subtests of the Sensory Integration and Praxis Test, (b) measurements of the Somatosensory Evoked Potential (SEP) and (c) ratings of the children's affective responses during tactile stimulation. Both ADHD groups differed from the control group on most study measures. No significant differences were found between the two ADHD subgroups on threshold and perceptual tests scores, except for Finger Identification. However, the TD+ group demonstrated significantly higher central SEP amplitudes than did the TD- group. Together, the results support claims that TD is related to central processing of somatosensory information, but not to anomalous tactile perception, with the exception of Finger Identification.

Piek, J. L., & Dyck, M. J. (2004). Sensory-motor deficits in children with developmental coordination disorder, attention deficit hyperactivity disorder and autistic disorder. *Human Movement Science*, 23, 475-488.

This article was a critical discussion of relevant literature and the authors' recent research studies in regards to the authors' postulate that deficient sensory-motor functioning in children can aid in detecting the presence or absence of comorbid developmental disorders. The authors investigated the developmental disorders of developmental coordination disorder (DCD), attention deficit hyperactivity disorder (ADHD) and autistic disorder in children. The authors found support for the association of DCD with deficits in visual-spatial processing, kinesthetic perception (particularly related to active movement), and cross-modal integration of kinesthetic information with other sensory information. Research findings on the degree of competency of kinesthetic perception and visual-motor skills in children with ADHD have not been consistent, possibly due to the failure of most researchers to separate the research population of children with ADHD into

groups with and without ADHD. Children with ADHD do frequently demonstrate slower processing speed. The motor skill deficiencies in children with ADHD have often been attributed to their distractibility and impulsiveness. These authors investigated this postulate. They found that only children who had comorbid diagnoses of DCD and ADHD had significantly poorer results on a test of fine motor ability than the control subjects and children with only the diagnosis of ADHD. In another study by these authors, they found that children with both diagnoses of DCD and ADHD performed more poorly to a significant degree on measures of visuospatial organization than the children with ADHD alone or the control group. A meta-analysis done by Pennington and Ozonoff (1996) was stated to indicate that children with ADHD tend to have adequate visual-spatial perception, but have difficulty with executive functioning (e.g., working memory, response inhibition, and planning action sequences). The findings of research studies on children with autism indicate that if both motor coordination and perceptual abilities are markedly deficient, more severe symptoms are manifested. There has been an association established between difficulties in motor coordination and empathic abilities. Children with DCD may have poor social skills partially due to their inadequate visual-spatial integration contributing to problems in perceiving non-verbal, emotional cues. These authors propose that the presence of a comorbid condition of DCD in some children with autism may be contributing to the severity of impairment in those children.

SIGN note: This article supports the Ayres' SI principles of deficits in sensory integration contributing to problems in motor coordination, deficits in visual-spatial perception and kinesthetic perception being associated with poor motor skills, and difficulties with sensory processing and motor coordination contributing to problems in social interaction. The article indirectly supports the possible appropriateness of the sensory integrative treatment approach with children having DCD and those having a comorbid diagnosis of autism or ADHD. There was a report of a research finding that children with ADHD tend to have significant difficulty with planning action sequences. This finding also indirectly supports the use of the SI treatment approach with some children with ADHD.

Reviewed by Katherine Inamura, 11/15/2005

Molloy, C. A., Kietrich, K. N., & Bhattacharya, A. (2003). Postural stability in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 33(6), 643-652.

Eight boys identified as having Autism Spectrum Disorder (ASD) and eight controls matched for age, race, and gender took part in this study of postural stability. The subjects with ASD were recruited from children diagnosed or receiving speech therapy at the Kelly O'Leary Center for Pervasive Developmental Disorder of the Children's Hospital Medical Center of

Cincinnati, Ohio. They all had a receptive language age of at least 4 years and ranged in age from 7 years to 12 years old. After selection for the study, the boys with ASD were rated on a parent questionnaire concerning their general performance for typical childhood motor activities. Their composite scores for running, climbing, and stair climbing did not vary significantly from the scores given to the controls. Measurements of the postural sway of the subjects were taken using force platform technology under conditions that removed or changed visual and somatosensory input. In comparison with the neurologically typical controls, the boys with ASD had greater postural sway when vision was occluded and somatosensory information was altered. The subjects with ASD had more difficulty maintaining their upright balance than the controls when vision cues were eliminated, whether or not the somatosensory input was altered or not. The researchers concluded that the study results supported the postulates that children with ASD tend to over-rely on visual information and that they have a deficit in sensory integration rather than a deficit in a particular afferent sensory system.

SIGN note: The study findings seem to support the Ayres' SI postulate that children with ASD have deficits in sensory integration contributing to balance difficulties. However, the study does not provide a link between difficulties in balance and sensory integration to problems in functional activities. It does provide evidence that some children with ASD are overdependent on visual cues for maintaining their balance. The study is limited by the small number of subjects and the use of an apparently nonstandardized questionnaire to assess the presence of motor deficits.
Reviewed by Katherine Inamura, 10/28/2005

Gillberg, C., & Kadesjo, B. (2003). Why bother about clumsiness? The implications of having developmental coordination disorder (DCD). *Neural Plasticity*, 10, 59-68.

This article consists of a review of several research studies focusing on a common motor problem currently affecting many school-aged children, called Developmental Coordination Disorder (DCD). More specifically, the authors use past research to create a link between DCD and behavior problems such as ADHD and autism. According to the DSM IV, children with DCD are well below their chronological age or measured intelligence when performing daily activities that require motor coordination, such as handwriting or sports. Researchers trying to uncover the etiology of DCD have pointed at theories of "processing deficits," which may cause a reduction in the rate of information processing or create difficulty in handling spatial information that is related to the control of movement. More specifically, researchers have found a greater frequency of visuospatial

discrimination impairments and dysfunction of kinesthetic perceptions in children with DCD. In addition, research has shown a high rate of DCD as a comorbid condition in children with ADHD and autism spectrum disorders. In fact, in about fifty percent of all cases ADHD is associated with DCD. Therefore, the authors of this article suggest the need to further study the correlation between these diagnoses. For instance they point to the need to investigate how the treatment of one deficit, e.g. attention, may help alleviate several other problems, e.g. motor control.

Astill, S., & Utley, A. (2006). Two-handed catching in children with developmental coordination disorder. *Motor Control*, 10(2), 109-124.

This study investigated the nature and extent of inter and intralimb coupling of the upper limbs in children with developmental coordination disorder (DCD) and their age-matched controls (AMC) when catching a ball twohanded. Sixteen children (8 DCD, 8 AMC) volunteered for the study; parental consent was gained for each child. Using standard video analysis and 3D kinematic analysis, all children were examined performing 30 twohanded catches. Video analysis showed that the AMC children caught more balls than the DCD children ($p < .005$). Analyses of the kinematic data showed DCD participants exhibit a greater degree of linkage both between and within limb than the AMC participants ($p < .01$), but the AMC participants demonstrate more intra individual variability in these linkages ($p < .01$). The data shows that both DCD and AMC children couple their limbs to exert control over redundant degrees of freedom when catching a ball two-handed. However, DCD children show little capacity to vary their motor behavior exhibiting a less adaptable movement system, which in turn affects their success at the task.