Neuroscience and other research that may be related to sensory processing / sensory integration theory.

2009

Stein BE, Perrault TJ Jr, Stanford TR, & Rowland BA. (2009). Postnatal experiences influence how the brain integrates information from different senses. Front Integr Neurosci. 3:21. Epub 2009 Sep 30.

Sensory processing disorder (SPD) is characterized by anomalous reactions to, and integration of, sensory cues. Although the underlying etiology of SPD is unknown, one brain region likely to reflect these sensory and behavioral anomalies is the superior colliculus (SC), a structure involved in the synthesis of information from multiple sensory modalities and the control of overt orientation responses. In the present review we describe normal functional properties of this structure, the manner in which its individual neurons integrate cues from different senses, and the overt SC-mediated behaviors that are believed to manifest this "multisensory integration." Of particular interest here is how SC neurons develop their capacity to engage in multisensory integration during early postnatal life as a consequence of early sensory experience, and the intimate communication between cortex and the midbrain that makes this developmental process possible.

Miller LJ, Nielsen DM, Schoen SA, & Brett-Green BA. (2009). Perspectives on sensory processing disorder: a call for translational research. Front Integr Neurosci.3:22. Epub 2009 Sep 30.

THIS ARTICLE EXPLORES THE CONVERGENCE OF TWO FIELDS, WHICH HAVE SIMILAR THEORETICAL ORIGINS: a clinical field originally known as sensory integration and a branch of neuroscience that conducts research in an area also called sensory integration. Clinically, the term was used to identify a pattern of dysfunction in children and adults, as well as a related theory, assessment, and treatment method for children who have atypical responses to ordinary sensory stimulation. Currently the term for the disorder is sensory processing disorder (SPD). In neuroscience, the term sensory integration refers to converging information in the brain from one or more sensory domains. A recent subspecialty in neuroscience labeled multisensory integration (MSI) refers to the neural process that occurs when sensory input from two or more different sensory modalities converge. Understanding the specific meanings of the term sensory integration intended by the clinical and neuroscience fields and the term MSI in neuroscience is critical. A translational research approach would improve exploration of crucial research questions in both the basic

science and clinical science. Refinement of the conceptual model of the disorder and the related treatment approach would help prioritize which specific hypotheses should be studied in both the clinical and neuroscience fields. The issue is how we can facilitate a translational approach between researchers in the two fields. Multidisciplinary, collaborative studies would increase knowledge of brain function and could make a significant contribution to alleviating the impairments of individuals with SPD and their families.

Weierich MR, Wright CI, Negreira A, Dickerson BC, & Barrett LF. (2009). Novelty as a dimension in the affective brain. Neuroimage. Sep 28. [Epub ahead of print]

Many neuroscience studies have demonstrated that the human amygdala is a central element in the neural workspace that computes affective value. Emerging evidence suggests that novelty is an affective dimension that engages the amygdala independently of other affective properties. This current study is the first in which novelty, valence, and arousal were systematically examined for their relative contributions to amygdala activation during affective processing. Healthy young adults viewed International Affective Picture System (IAPS) images that varied along the dimensions of valence (positive, negative, neutral), arousal (high, mid, low), and novelty (novel, familiar). The results demonstrate that, in comparison to negative (vs. positive) and high (vs. low) arousal stimuli, the amygdala has higher peak responses and a selectively longer time course of activation to novel (vs. familiar) stimuli. In addition, novelty differentially engaged other affective brain areas including those involved in controlling and regulating amygdala responses (e.g., orbitofrontal cortex), as well as those transmitting sensory signals that the amygdala modulates (e.g., occipitotemporal visual cortex). Taken together with other findings, these results support the idea that an essential amygdala function is signaling stimulus importance or salience. The results also suggest that novelty is a critical stimulus dimension for amygdala engagement (in addition to valence and arousal).

Fetsch CR, Turner AH, DeAngelis GC, & Angelaki DE. (2009). Dynamic reweighting of visual and vestibular cues during self-motion perception. J Neurosci. 9;29(49):15601-12.

The perception of self-motion direction, or heading, relies on integration of multiple sensory cues, especially from the visual and vestibular systems. However, the reliability of sensory information can vary rapidly and unpredictably, and it remains unclear how the brain integrates multiple sensory signals given this dynamic uncertainty. Human psychophysical studies have shown that observers combine cues by weighting them in proportion to their

reliability, consistent with statistically optimal integration schemes derived from Bayesian probability theory. Remarkably, because cue reliability is varied randomly across trials, the perceptual weight assigned to each cue must change from trial to trial. Dynamic cue reweighting has not been examined for combinations of visual and vestibular cues, nor has the Bayesian cue integration approach been applied to laboratory animals, an important step toward understanding the neural basis of cue integration. To address these issues, we tested human and monkey subjects in a heading discrimination task involving visual (optic flow) and vestibular (translational motion) cues. The cues were placed in conflict on a subset of trials, and their relative reliability was varied to assess the weights that subjects gave to each cue in their heading judgments. We found that monkeys can rapidly reweight visual and vestibular cues according to their reliability, the first such demonstration in a nonhuman species. However, some monkeys and humans tended to over-weight vestibular cues, inconsistent with simple predictions of a Bayesian model. Nonetheless, our findings establish a robust model system for studying the neural mechanisms of dynamic cue reweighting in multisensory perception.

Hofer SB, Mrsic-Flogel TD, Bonhoeffer T, & Hübener M.(2009). Experience leaves a lasting structural trace in cortical circuits. Nature. 457(7227):313-7. Epub 2008 Nov 12.

Sensory experiences exert a powerful influence on the function and future performance of neuronal circuits in the mammalian neocortex. Restructuring of synaptic connections is believed to be one mechanism by which cortical circuits store information about the sensory world. Excitatory synaptic structures, such as dendritic spines, are dynamic entities that remain sensitive to alteration of sensory input throughout life. It remains unclear, however, whether structural changes at the level of dendritic spines can outlast the original experience and thereby provide a morphological basis for long-term information storage. Here we follow spine dynamics on apical dendrites of pyramidal neurons in functionally defined regions of adult mouse visual cortex during plasticity of eye-specific responses induced by repeated closure of one eye (monocular deprivation). The first monocular deprivation episode doubled the rate of spine formation, thereby increasing spine density. This effect was specific to layer-5 cells located in binocular cortex, where most neurons increase their responsiveness to the non-deprived eye. Restoring binocular vision returned spine dynamics to baseline levels, but absolute spine density remained elevated and many monocular deprivation-induced spines persisted during this period of functional recovery. However, spine addition did not increase again when the same eye was closed for a second time. This absence of structural plasticity stands out against the robust changes of eye-specific responses that occur even faster after repeated deprivation. Thus, spines added during the first monocular deprivation experience may provide a structural basis for

subsequent functional shifts. These results provide a strong link between functional plasticity and specific synaptic rearrangements, revealing a mechanism of how prior experiences could be stored in cortical circuits.

Simon-Dack SL, Cummings SE, Reetz DJ, Alvarez-Vazquez E, Gu H, Teder-Sälejärvi WA. (2009). "Touched" by light: event-related potentials (ERPs) to visuo-haptic stimuli in peri-personal space. Brain Topogr. 21(3-4):261-8. Epub 2009 Apr 29.

Parietal neuronal populations have been found which respond bimodally to visual and somatosensory input regarding one's own limbs or even perceived haptic input of a false limb (Graziano et al., Science 290:1782-1785, 2000). Further, neuronal populations have been observed which respond preferentially to visual stimuli presented in spatial congruence with our hands (Graziano, Proc Natl Acad Sci USA 96:10418-10421, 1999). In this study, we examined event-related potentials (ERPs) elicited by laser dots projected onto or above participants' index and middle fingers during a sustained-attention task. We hypothesized that visual stimuli projected onto the hand would elicit differences in ERP deflections related to sensory gating and categorization in comparison to when projected close to the hand. Participants responded via a footswitch to rare target flashes of light occurring on or directly above the middle finger of the attended hand. We found enhanced amplitudes of the N1 and P3 deflections when the stimuli fell onto the finger tips as opposed to above them. Furthermore, the N1 for unattended stimuli was less suppressed when the lasers were projected onto the fingers. Behaviorally, participants were less accurate to targets when the lasers fell onto the fingers. We conclude that when the lasers appear to "touch" the participants, they act to automatically draw participants' attention. Thus visual stimuli projected onto the fingers of the 'unattended' hand are harder to filter out, leading to decreases in accuracy during task performance.

Lijffijt M, Lane SD, Meier SL, Boutros NN, Burroughs S, Steinberg JL, Gerard Moeller F, Swann AC. (2009). P50, N100, and P200 sensory gating: relationships with behavioral inhibition, attention, and working memory. Psychophysiology. 46(5):1059-68. Epub 2009 Jun 8.

P50, N100, and P200 auditory sensory gating could reflect mechanisms involved in protecting higher-order cognitive functions, suggesting relationships between sensory gating and cognition. This hypothesis was tested in 56 healthy adults who were administered the paired-click paradigm and two adaptations of the continuous performance test (Immediate/Delayed Memory Task, IMT/DMT).

Stronger P50 gating correlated with fewer commission errors and prolonged reaction times on the DMT. Stronger N100 and P200 gating correlated with better discriminability on the DMT. Finally, prolonged P200 latency related to better discriminability on the IMT. These findings suggest that P50, N100, and P200 gating could be involved in protecting cognition by affecting response bias, behavioral inhibition, working memory, or attention.

Klemen J, Büchel C, Rose M.(2009). Perceptual load interacts with stimulus processing across sensory modalities. Eur J Neurosci. 29(12):2426-34. Epub 2009 May 26.

According to perceptual load theory, processing of task-irrelevant stimuli is limited by the perceptual load of a parallel attended task if both the task and the irrelevant stimuli are presented to the same sensory modality. However, it remains a matter of debate whether the same principles apply to cross-sensory perceptual load and, more generally, what form cross-sensory attentional modulation in early perceptual areas takes in humans. Here we addressed these questions using functional magnetic resonance imaging. Participants undertook an auditory one-back working memory task of low or high perceptual load, while concurrently viewing task-irrelevant images at one of three object visibility levels. The processing of the visual and auditory stimuli was measured in the lateral occipital cortex (LOC) and auditory cortex (AC), respectively. Cross-sensory interference with sensory processing was observed in both the LOC and AC, in accordance with previous results of unisensory perceptual load studies. The present neuroimaging results therefore warrant the extension of perceptual load theory from a unisensory to a cross-sensory context: a validation of this cross-sensory interference effect through behavioural measures would consolidate the findings.

Alvarado JC, Stanford TR, Rowland BA, Vaughan JW, Stein BE. (2009). Multisensory integration in the superior colliculus requires synergy among corticocollicular inputs. J Neurosci. 29(20):6580-92.

Influences from the visual (AEV), auditory (FAES), and somatosensory (SIV) divisions of the cat anterior ectosylvian sulcus (AES) play a critical role in rendering superior colliculus (SC) neurons capable of multisensory integration. However, it is not known whether this is accomplished via their independent sensory-specific action or via some cross-modal cooperative action that emerges as a consequence of their convergence on SC neurons. Using visual-auditory SC neurons as a model, we examined how selective and combined

deactivation of FAES and AEV affected SC multisensory (visual-auditory) and unisensory (visual-visual) integration capabilities. As noted earlier, multisensory integration yielded SC responses that were significantly greater than those evoked by the most effective individual component stimulus. This multisensory "response enhancement" was more evident when the component stimuli were weakly effective. Conversely, unisensory integration was dominated by the lack of response enhancement. During cryogenic deactivation of FAES and/or AEV, the unisensory responses of SC neurons were only modestly affected; however, their multisensory response enhancement showed a significant downward shift and was eliminated. The shift was similar in magnitude for deactivation of either AES subregion and, in general, only marginally greater when both were deactivated simultaneously. These data reveal that SC multisensory integration is dependent on the cooperative action of distinct subsets of unisensory corticofugal afferents, afferents whose sensory combination matches the multisensory profile of their midbrain target neurons, and whose functional synergy is specific to rendering SC neurons capable of synthesizing information from those particular senses.

Werkhoven PJ, van Erp JB, Philippi TG.(2009). Counting visual and tactile events: the effect of attention on multisensory integration. Atten Percept Psychophys. 71(8):1854-61.

Irrelevant events in one sensory modality can influence the number of events that are perceived in another modality. Previously, the underlying process of sensory integration was studied in conditions in which participants knew a priori which sensory modality was relevant and which was not. Consequently, (bottom-up) sensory interference and (top-down) selective attention were confounded. We disentangled these effects by measuring the influence of visual flashes on the number of tactile taps that were perceived, and vice versa, in two conditions. In the cue condition, participants were instructed on which modality to report before the bimodal stimulus was presented. In the no-cue condition, they were instructed after stimulus presentation. Participants reported the number of events that they perceived for bimodal combinations of one, two, or three flashes and one, two, or three taps. Our main findings were that (1) in no-cue conditions, the influence of vision on touch was stronger than was the influence of touch on vision; (2) in cue conditions, the integration effects were smaller than those in no-cue conditions; and (3) irrelevant taps were less easily ignored than were irrelevant flashes. This study disentangled previously confounded bottom-up and top-down effects: The bottom-up influence of vision on touch was stronger, but vision was also more easily suppressed by top-down selective attention. We have compared our results qualitatively and quantitatively with recently proposed sensory-integration models.

Sarlegna, F.R., Przybyla, A., Sainburg, R.L. (2009). The influence of target sensory modality on motor planning may reflect errors in sensori-motor transformations. Nueroscience 164 (2), pp. 597-610

Multi-***sensory integration*** studies have shown that combining heterogeneous signals can optimize motor performance by reducing errors inherent to any single modality. However, it has also been suggested that errors could arise from erroneous transformations between heterogeneous coordinate systems. Here we investigated the effect of visuo-proprioceptive ***integration*** on the control of multi-joint arm movements by manipulating target modality. When the target was visual, movement control required the ***integration*** of visual target signals with proprioceptive signals about limb configuration. In contrast, when the target was the unseen fingertip, movement control relied solely on proprioceptive signals since visual feedback of hand position was precluded. We hypothesized that a faulty ***integration*** of visual target signals with proprioceptive arm signals would result in a less accurate planning of visually-targeted movements with respect to proprioceptively-targeted movements. Different inter-joint coordinations patterns were tested by varying starting hand position. Results showed larger initial trajectory deviations from target direction for visually-targeted movements involving substantial shoulder and elbow motions. Inverse dynamic analysis revealed that these deviations were associated with less efficient intersegmental coordination. The control of visually-targeted movements thus appeared sub-optimal compared to proprioceptively-targeted movements when considering theoretical models of motor planning assuming kinematic or dynamic optimizations. Additional experiments further highlighted the effect of target position, and visual feedback of starting hand position, on motor planning for proprioceptively- and visually-targeted movements. Our findings suggest that the ***integration*** of heterogeneous ***sensory*** signals related to hand and target positions introduces errors in motor planning.

Pennartz CM.(2009). Identification and integration of sensory modalities: neural basis and relation to consciousness. Conscious Cogn. 18(3):718-39. Epub 2009 May 5.

A key question in studying consciousness is how neural operations in the brain can identify streams of sensory input as belonging to distinct modalities, which contributes to the representation of qualitatively different experiences. The basis for identification of modalities is proposed to be constituted by self-organized comparative operations across a network of unimodal and multimodal sensory areas. However, such network interactions alone cannot

answer the question how sensory feature detectors collectively account for an integrated, yet phenomenally differentiated experiential content. This problem turns out to be different from, although related to, the binding problem. It is proposed that the neural correlate of an enriched, multimodal experience is constituted by the attractor state of a dynamic associative network. Within this network, unimodal and multimodal sensory maps continuously interact to influence each other's attractor state, so that a feature change in one modality results in a fast re-coding of feature information in another modality. In this scheme, feature detection is coded by firing-rate, whereas firing phase codes relational aspects.

Crepeau-Hobson, M. Franci (2009). The relationship between perinatal risk factors and sensory processing difficulties in preschool children. ; Journal of Developmental and Physical Disabilities, 21(4), 315-328. [Journal Article]

Abstract: This study examined the relationship between reported perinatal risk factors and sensory processing difficulties in young children. The biological mothers of 152 preschool-age children completed two measures: the Maternal Perinatal Scale (MPS), a maternal self-report that surveys complications of pregnancies and medical conditions of the mother, and the Short Sensory Profile (SSP), a measure designed to provide information about the child's ability to process sensory information and the sensory system's effect on functional performance. Using MPS factors as predictors, separate stepwise regression analyses for each SSP section showed early neonatal status, and prenatal and birth/delivery factors to hold the most significant implications for future sensory processing difficulties. Total number of perinatal risk factors was also found to significantly predict some SSP scores. Implications for intervention are discussed. (PsycINFO Database Record (c) 2009 APA, all rights reserved)

Jax SA, Coslett HB. (2009). Disorders of the perceptual-motor system. Adv Exp Med Biol. 629:377-91.

The study of patients with movement disorders provides insight into both the functional organization and the neural substrates of the perceptual-motor system. By and large, we feel this source of information has been underutilized within the basic science of motor control. To begin to address this shortcoming, this chapter reviews three disorders of the perceptual-motor system (disorders of the body schema, optic ataxia, and ideomotor apraxia) and illustrates how the study of these disorders can inform central issues within the field of motor control. These issues include (1) the need for the perceptual-motor system to maintain a representation of the body's current configuration in order to

produce movements, (2) the use of visual information in movement production, (3) the coordinate frame in which movements are controlled, (4) the distinction between movement planning and online correction, and (5) the role of the parietal cortex in action. In the conclusion, we discuss several limitations of studying patients with movement disorders as well as suggest that greater communication is needed between researchers in the basic science of motor control and clinicians developing treatments for movement disorders.

Diekhof EK, Biedermann F, Ruebsamen R, Gruber O. (2009). Top-down and bottom-up modulation of brain structures involved in auditory discrimination. Brain Res. 1297:118-23. Epub 2009 Aug 21.

Auditory deviancy detection comprises both automatic and voluntary processing. Here, we investigated the neural correlates of different components of the sensory discrimination process using functional magnetic resonance imaging. Subliminal auditory processing of deviant events that were not detected led to activation in left superior temporal gyrus. On the other hand, both correct detection of deviancy and false alarms activated a frontoparietal network of attentional processing and response selection, i.e. this network was activated regardless of the physical presence of deviant events. Finally, activation in the putamen, anterior cingulate and middle temporal cortex depended on factual stimulus representations and occurred only during correct deviancy detection. These results indicate that sensory discrimination may rely on dynamic bottom-up and top-down interactions.

van Ee R, van Boxtel JJ, Parker AL, Alais D. (2009). Multisensory congruency as a mechanism for attentional control over perceptual selection. J Neurosci. 16;29(37):11641-9.

The neural mechanisms underlying attentional selection of competing neural signals for awareness remains an unresolved issue. We studied attentional selection, using perceptually ambiguous stimuli in a novel multisensory paradigm that combined competing auditory and competing visual stimuli. We demonstrate that the ability to select, and attentively hold, one of the competing alternatives in either sensory modality is greatly enhanced when there is a matching cross-modal stimulus. Intriguingly, this multimodal

enhancement of attentional selection seems to require a conscious act of attention, as passively experiencing the multisensory stimuli did not enhance control over the stimulus. We also demonstrate that congruent auditory or tactile information, and combined auditory-tactile information, aids attentional control over competing visual stimuli and visa versa. Our data suggest a functional role for recently found neurons that combine voluntarily initiated attentional functions across sensory modalities. We argue that these units provide a mechanism for structuring multisensory inputs that are then used to selectively modulate early (unimodal) cortical processing, boosting the gain of task-relevant features for willful control over perceptual awareness.

Lemasson BH, Anderson JJ, Goodwin RA. (2009). Collective motion in animal groups from a neurobiological perspective: the adaptive benefits of dynamic sensory loads and selective attention. J Theor Biol. 261(4):501-10. Epub 2009 Aug 20.

We explore mechanisms associated with collective animal motion by drawing on the neurobiological bases of sensory information processing and decision-making. The model uses simplified retinal processes to translate neighbor movement patterns into information through spatial signal integration and threshold responses. The structure provides a mechanism by which individuals can vary their sets of influential neighbors, a measure of an individual's sensory load. Sensory loads are correlated with group order and density, and we discuss their adaptive values in an ecological context. The model also provides a mechanism by which group members can identify, and rapidly respond to, novel visual stimuli.

Lee LJ, Chen WJ, Chuang YW, Wang YC. (2009).Neonatal whisker trimming causes long-lasting changes in structure and function of the somatosensory system. Exp Neurol. 219(2):524-32. Epub 2009 Jul 18.

The significance of very early experience in the maturation of whisker-to-barrel system comes primarily from neonatal whisker or infraorbital nerve lesion studies conducted prior to the formation of cortical barrels. However, the surgical procedures damage the sensory pathway; it is difficult to examine the consequence after the recovery of sensory deprivation. To address this issue,

we performed a neonatal whisker-cut (WC) paradigm and examined their behavioral performance during P30 to P35. With fully regrown whiskers, the rats that had whisker cut from the date of birth (P0) to postnatal day (P) 3 (WC 0-3) exhibited shorter crossable distance in the gap-crossing test. However, the rats had whisker cut at P3 only (WC 3) behaved normally in this test, suggesting the critical period for the development of whisker-specific tactile function is P0-P3, agreed with previous findings demonstrated by lesion methods. In the WC 0-3 rats, the cortical areas in the layer IV somatosensory region in relation to the trimmed whiskers were enlarged and the spiny stellate neurons within had larger dendritic span and greater spine density. Furthermore, more long and multiple-head spines were found in these rats. With abnormal structure and function in the somatosensory system, the WC 0-3 rats showed higher explorative activity and more frequent social interactions. Our results have demonstrated that the early tactile deprivation, similar to early visual deprivation, perturbed the developmental program of the brain and affected later behaviors in various aspects.

Lee LJ. (2009). Neonatal fluoxetine exposure affects the neuronal structure in the somatosensory cortex and somatosensory-related behaviors in adolescent rats. Neurotox Res. 15(3):212-23. Epub 2009 Mar 4.

Selective serotonin reuptake inhibitor (SSRI)-type antidepressants are often prescribed to depressive pregnant women for their less adverse side effects. However, growing evidences have shown increased congenital malformations and poor neonatal adaptation in the perinatal SSRI-exposed human infants as well as animal pups. In this study, we examined the effects of early exposure of fluoxetine, the most popular SSRI-type antidepressant, on the developing somatosensory system. Physiological saline or fluoxetine (10 mg/kg) was subcutaneously injected into neonatal rats from P0 to P6. Somatosensory-related behaviors were examined in adolescence (P30-P35). Morphological features of the primary somatosensory cortex were checked at P7 and P35. The tactile and thermal perceptions as well as locomotor activity were affected by neonatal fluoxetine treatment. At the morphological level, the number of branch tips of thalamocortical afferents to the somatosensory cortex was reduced in the fluoxetine-treated rats. Furthermore, the spiny stellate neurons in the layer IV somatosensory cortex had reduced dendritic span and complexity with fewer branches, shorter dendritic length, and smaller dendritic field. The spine density of spiny stellate neurons was significantly reduced whereas the spine length of mushroom- and branched-type was increased. Taken together, these results indicate that neonatal fluoxetine administration has long-lasting effects on the function and structure in the somatosensory system. Sensory information processing may be disturbed in the neonatal fluoxetine-treated animals due to the structural deformation in the

thalamocortical afferents and dendritic structures of the spiny stellate neurons in the layer IV somatosensory cortex.

Pinkernelle J, Abraham A, Seidel K, Braun K. (2009). Paternal deprivation induces dendritic and synaptic changes and hemispheric asymmetry of pyramidal neurons in the somatosensory cortex. Dev Neurobiol. 69(10):663-73.

Similar to maternal care, paternal care is a source of neonatal sensory stimulation, which in primates and rodents has been shown to be essential for developing structure and function of sensory cortices. The aim of our study in the biparental rodent Octodon degus was to assess the impact of paternal deprivation on dendritic and synaptic development in the somatosensory cortex. We (i) quantified the amount of paternal care in relation to total parental investment and (ii) compared dendritic and synaptic development of pyramidal neurons in the somatosensory cortex of animals raised by a single mother or by both parents. On the behavioral level we show that paternal care comprises 37% of total parent-offspring interactions, and that the somatosensory stimulation provided by the fathers primarily consists of huddling, licking/grooming, and playing. On the morphological level we found that, compared with offspring raised by both parents (mother and father), the father-deprived animals displayed significantly reduced spine numbers on the basal dendrites of pyramidal neurons. Furthermore, paternal deprivation induces hemispheric asymmetry of the dendritic morphology of somatosensory pyramidal neurons. Father-deprived animals show shorter and less complex basal dendrites in the left somatosensory cortex compared with the right hemisphere. These findings indicate that paternal deprivation results in delayed or retarded dendritic and synaptic development of somatosensory circuits.

Restuccia D, Zanini S, Cazzagon M, Del Piero I, Martucci L, Della Marca G. (2009). Somatosensory mismatch negativity in healthy children. Dev Med Child Neurol. 51(12):991-8.

AIM: Event-related potentials (ERPs) obtained when focused attention is kept away from the stimulus (unnoticed stimulation) are possibly linked to automatic mismatch-detection mechanisms, and could be a useful tool to investigate sensory discrimination ability. By considering the high impact of impaired somatosensory integration on many neurological disturbances in children, we aimed to verify whether mismatch-related responses to somatosensory stimulation could be obtained in healthy children. METHOD:

Eleven healthy participants (age range 6-11y, mean 8y 2mo, SD 1y 7mo; seven males, four females) underwent 'oddball' electrical stimulation of the right hand (80% frequent stimuli delivered to the thumb, 20% deviant stimuli delivered to the fifth finger). Data were compared with those obtained when the frequent stimuli to the thumb were omitted ('standard-omitted' protocol). ERPs were recorded at frontal, central, and parietal scalp locations. Children's overt attention was engaged by a demanding video game. RESULTS: In the oddball protocol, deviant stimulation elicited a left central negativity at about 160ms latency, followed by a left frontal negative response at about 220ms latency. Standard-omitted traces showed only a left parietal negative response spreading to right parietal regions. INTERPRETATION: Mismatch-related somatosensory responses can be reliably obtained in children, providing that appropriate technical contrivances are used. In clinical use, the frontal components, which are present only during the oddball protocol, could be a reliable and unequivocal neurophysiological marker of the automatic mismatch-detection mechanism.

Block HJ, Bastian AJ. (2009). Sensory reweighting in targeted reaching: Effects of conscious effort, error history, and target salience. J Neurophysiol. Oct 21. [Epub ahead of print]

When both visual and proprioceptive information are available about the position of a part of the body, the brain weights and combines these sources to form a single estimate, often modeled by minimum variance integration. These weights are known to vary with different circumstances, but the type of information causing the brain to change weights (reweight) is unknown. Here we studied reweighting in the context of estimating the position of a hand for the purpose of reaching it with the other hand. Subjects reached to visual (V), proprioceptive (P), or combined (VP) targets in a virtual reality setup. We calculated weights for vision and proprioception by comparing endpoints on VP reaches with endpoints on P and V reaches. Endpoint visual feedback was manipulated to control completely for the error history seen by subjects. In different experiments, we manipulated target salience, conscious effort, or statistics of the visual error history to see if these cues could cause reweighting. Most subjects could reweight strongly by conscious effort. Changes in target salience reliably caused reweighting, but seen error history alone did not. We also found that experimental weights can be predicted by minimizing the variance of visual and proprioceptive estimates, supporting the idea that minimum variance integration is an important principle of sensorimotor processing.

Withagen R, van Wermeskerken M. (2009). Individual differences in learning to perceive length by dynamic touch: evidence for variation in perceptual learning capacities. Atten Percept Psychophys. 71(1):64-75.

Recent studies of perceptual learning have explored and commented on variation in learning trajectories. Although several factors have been suggested to account for this variation, thus far the idea that humans vary in their perceptual learning capacities has received scant attention. In the present experiment, we aimed at providing a detailed picture of the variation in this capacity by investigating the perceptual learning trajectories of a considerable number of participants. The learning process was studied using the paradigm of length perception by dynamic touch. The results showed that there are substantial individual differences in the way perceivers respond to feedback. Indeed, after feedback, the participants' perceptual performances diverged. We conclude that humans vary in their perceptual learning capacities. The implications of this finding for recent discussions on variation in perception are explored.

Prior to 2009

Benjamin A. Rowland* and Barry E. Stein (2008) Temporal profiles of response enhancement in multisensory integration Frontiers in Neuroscience www.frontiersin.org 2(2), 218

Animals have evolved multiple senses that transduce different forms of energy as a way of increasing their sensitivity to environmental events. Each sense provides a unique and independent perspective on the world, and very often a single event stimulates several of them. In order to make best use of the available information, the brain has also evolved the capacity to integrate information across the senses ("multisensory integration"). This facilitates the detection, localization, and identification of a given event, and has obvious survival value for the individual and the species. Multisensory responses in the superior colliculus (SC) evidence shorter latencies and are more robust at their onset. This is the phenomenon of initial response enhancement in multisensory integration, which is believed to represent a real time fusion of information across the senses. The present paper reviews two recent reports describing how the timing and robustness of sensory responses

change as a consequence of multisensory integration in the model system of the SC.

Bradley, M. M., Lang, P. J., & Cuthbert, B. N. (1993). Emotion, novelty, and the startle reflex: habituation in humans. Behav Neurosci, 107(6), 970-980.

Previous research with both animal and human subjects has shown that startle reflex magnitude is potentiated in an aversive stimulus context, relative to responses elicited in a neutral or appetitive context. In the present experiment, the same pleasant, unpleasant, and neutral picture stimuli were repeatedly presented to human subjects. Startle reflex habituation was assessed in each stimulus context and was compared with the habituation patterns of heart rate, electrodermal, and facial corrugator muscle responses. All systems showed initial differentiation among affective picture contents and general habituation over trials. The startle reflex alone, however, continued to differentiate among pleasant, neutral, and unpleasant pictures throughout the presentation series. These results suggest that (a) the startle probe reflex is relatively uninfluenced by stimulus novelty, (b) the startle modulatory circuit (identified with amygdala-reticular connections in animals) varies systematically with affective valence, and (c) the modulatory influence is less subject to habituation than is the obligatory startle pathway or responses in other somatic and autonomic systems.

Garralda, M. E., Connell, J., & Taylor, D. C. (1991). Psychophysiological anomalies in children with emotional and conduct disorders. Psychol Med, 21(4), 947-957.

We studied patterns of psychophysiological (skin conductance, heart rate) reactivity to sounds and to situations with varying emotional and alerting connotations in child psychiatric outpatients and in healthy controls. Children with emotional disorders were particularly reactive to situations with aversive components, while conduct disorder subjects showed increased reactivity to pleasant situations and decreased responses to neutral but high-intensity stimulation and to withdrawal of stimulation in silence periods. The results indicate patterns of biological reactivity which may underlie different psychiatric disturbances in children.

Khalfa, S., Isabelle, P., Jean-Pierre, B., & Manon, R. (2002). Eventrelated skin conductance responses to musical emotions in humans. Neurosci Lett, 328(2), 145-149.

While the reasons underlying musical emotions are unclear, music is nevertheless a powerful elicitor of emotion, and as such, may induce

autonomic nervous system responses. One typical measure of this neural pathway is the skin conductance response (SCR). This response generally depends upon stimulus arousal, one of the two motivational determinants of emotion. The objective of the present study was to verify whether emotional reactions to music elicit such event-related autonomic responses. To this aim, four musical emotions varying in arousal were employed: fear, happiness, sadness and peacefulness. SCRs were found to be greater with the two more stimulating emotions, fear and happiness, as compared to the two more relaxing emotions, sadness and peacefulness ($P<0.05$). In addition, subjects' ratings of the emotional clarity for each excerpt did not parallel the corresponding SCRs magnitudes. The results show that SCRs can be evoked and modulated by musical emotional arousal, but are not sensitive to emotional clarity. While several studies have been performed with visual scenes and environmental sounds, the present study brings similar evidence from the musical domain.

Buhlmann, U., Wilhelm, S., Deckersbach, T., Rauch, S. L., Pitman, R. K., & Orr, S. P. (2007). Physiologic responses to loud tones in individuals with obsessive-compulsive disorder. Psychosom Med, 69(2), 166-72.

OBJECTIVE: To determine if individuals with obsessive-compulsive disorder (OCD) are characterized by larger eyeblink and/or autonomic responses to sudden, loud (startling) tones. METHODS: Twenty participants with OCD and 21 mentally healthy control participants were presented with 15 consecutive 95-db, 500-msec, 1000-Hz tones with 0-msec rise and fall times at the same time orbicularis oculi electromyogram (EMG), heart rate (HR), and skin conductance (SC) responses were measured. RESULTS: Participants with OCD produced larger average HR responses and a slower decline in SC responses across the 15-tone presentations. A trend for larger than average eyeblink EMG responses in participants with OCD was also observed. CONCLUSION: These results provide laboratory support for enhanced HR reactivity and a slower decline in SC responses to startling stimuli in individuals with OCD.

Sánchez-Navarro, J. P., Martínez-Selva, J.M., & Román, F. (2006). Uncovering the relationship between defence and orienting in emotion: cardiac reactivity to unpleasant pictures. Int J Psychophysiol, 61(1), 34-46.

This research was aimed at studying the relationship between the cardiovascular reactivity to an intense auditory stimulus and the subsequent cardiac response evoked by affective visual stimuli in fifty-five subjects who underwent a cardiac reactivity task (presentation of an intense acoustic stimulus), followed by a picture viewing task (54 pictures selected from the

International Affective Picture System). Heart rate (HR), electrodermal activity and corrugator supercilii electromyographic activity were recorded. Subjects were divided into two groups - high accelerators and low accelerators - on the basis of the first heart rate acceleration obtained in the cardiac reactivity task. Pictures evoked different cardiac response patterns in each subject group. Unpleasant pictures promoted a lower initial HR deceleration and a higher final acceleration in high accelerators than in low accelerators. This pattern of response was more marked with body damage pictures. Moreover, a relationship was found between the first acceleration promoted by the acoustic stimulus and the HR response waveform to the body damage pictures. These results show that, in an unselected sample of subjects, a subgroup tended to respond to loud stimuli with higher HR acceleration and sympathetic activation and to respond defensively to unpleasant pictures (as found by less initial HR deceleration and higher final HR acceleration), rather than manifesting an orienting response. The elicitation of the defence response by a brain fear system, in which the amygdala is a key structure, is also discussed.

Lipp, O. V., Siddle, D. A., Dall, P.J. (1997). The effect of emotional and attentional processes on blink startle modulation and on electrodermal responses. Psychophysiology, 34(3), 340-347.

Emotional accounts of startle modulation predict that startle is facilitated if elicited during aversive foreground stimuli. Attentional accounts hold that startle is enhanced if startle-eliciting stimulus and foreground stimulus are in the same modality. Visual and acoustic foreground stimuli and acoustic startle probes were employed in aversive differential conditioning and in a stimulus discrimination task. Differential conditioning was evident in electrodermal responses and blink latency shortening in both modalities, but effects on magnitude facilitation were found only for visual stimuli. In the discrimination task, skin conductance responses, blink latency shortening, and blink magnitude facilitation were larger during to-be-attended stimuli regardless of stimulus modality. The present results support the notion that attention and emotion can affect blink startle modulation during foreground stimuli.

Vianna, E. P., & Tranel, D. (2006). Gastric myoelectrical activity as an index of emotional arousal. Int J Psychophysiol, 61(1), 70-76.

Autonomic nervous system parameters such as electrodermal activity, heart rate, and facial EMG have been utilized extensively as measures of emotional arousal. One measure that has rarely been employed in this setting is gastric myoelectrical activity, despite the fact that "gut feelings" have an obvious and even profound role in everyday emotional life. It has been shown that the gastrointestinal system changes wall tonus and contraction rate during stressful tasks. However, the effects of emotionally salient

stimuli on gastrointestinal motility have scarcely been studied. In the current study, emotional film clips designed to elicit happiness, disgust, fear, sadness, or no emotion (neutral) were presented to 16 normal participants. Electrogastrogram (EGG), skin conductance, and heart rate were measured while the participants viewed the film clips, and participants rated subjective arousal intensity and pleasantness of the film clips. We found that emotional film clips reliably induced the intended subjective feeling states. Also, EGG peak amplitudes in fear, disgust, sadness and happiness were higher than in the no emotion condition. There was a strong positive correlation (r=0.64) between EGG peak amplitude and subjective ratings of arousal. This is the first evidence that gastric myoelectrical activity is strongly correlated with arousal ratings to emotionally salient stimuli, and it suggests that EGG may add useful information about how the body contributes to the phenomenology of emotion and feeling.

Tieman, J. G., Peacock, L. J., Cureton, K. J., & Dishman, R. K. (2001). Acoustic startle eyeblink response after acute exercise. Int J Neurosci, 106(1-2), 21-33.

The acoustic startle eyeblink response (ASER) is a useful probe for investigating central nervous system activity associated with emotional responses to aversive and appetitive stimuli. Though the ASER is sensitive to change in emotional arousal, the effect of acute physical exertion on ASER has not been reported. We examined changes in ASER amplitude and latency in 26 healthy young men (24+/-5 yr) after 20 min of cycling at light and hard intensities (40% and 75% VO2peak) and after 20 min of quiet rest. Mixed model ANCOVA, controlling precondition scores, indicated no effects for ASER amplitude or latency in either sedentary or active participants (p>.10). Our findings indicate that possible effects of acute exercise on potentiated startle or ASER responses elicited by positive or negative foreground stimuli should not be expected to be confounded by an altered baseline acoustic startle eyeblink response when measured in healthy young men.

Skolnick, A. I., & Davidson, R. I. (2002). Affective modulation of eyeblink startle with reward and threat. Psychophysiology, 39(6), 835-850.

An emotion-modulated acoustic startle paradigm for inducing positive and negative affect was used to address pregoal and postgoal affect. Participants played a computerized lottery task in which they chose digits that could match a subsequently displayed, random set of numbers. In the positive conditions, matches led to monetary rewards. In the negative condition, matches led to an aversive noise blast. In three experiments, we found eyeblink startle magnitude was potentiated just prior to feedback concerning reward outcome, suppressed following the feedback that a monetary reward

was won, and potentiated when threatened with an aversive noise. When presented with a 0%, 45%, 90%, or 100% chance of winning, higher probabilities suppressed startle response after feedback whereas the 45% trials did not. These data indicate that postgoal positive affect (winning reward) reliably suppressed the startle response whereas pregoal positive affect did not.

Sethre-Hofstad, L., Stansbury, K., & Rice, M. A. (2002). Attunement of maternal and child adrenocortical response to child challenge. Psychoneuroendocrinology, 27(6), 731-47.

Although a great deal is known about physiological responding to stress in nonhuman animals, and also about individual differences in behavioral attunement in humans, physiological attunement between human mothers and their children has never been studied. The current study examined attunement in adrenocortical response between mother and child in the context of the child's exposure to a novel and potentially challenging task. Children ranging in age from two to four years of age walked on a balance beam for the first time while mothers watched on a monitor from the next room. Saliva samples were collected from both mothers and children before and 30 minutes following the beam walk. Individual differences in behavioral attunement were assessed from a videotaped mother-child teaching task, and coded for maternal sensitivity. We expected that mothers rated as highly sensitive would show better physiological attunement with their children's adrenocortical response to the balance beam walk than less sensitive mothers. We did not expect that all children would show a cortisol elevation in response to the task. Rather, we were interested in the degree to which mothers "matched" children's adrenocortical fluctuations, regardless of elevations or decreases in cortisol. Results supported the hypothesis. In the highly sensitive group, mothers' and children's adrenocortical responses to the child beam walk were significantly correlated, and in the less sensitive group the responses were not significantly related. Findings suggest that physiological attunement may co-occur with behavioral sensitivity in normal mother-child relationships.

Elsner, B., Hommel, B., Mentschel, C., Drzezga, A., Prinz, W., Conrad, B., & Siebner, H. (2002). Linking actions and their perceivable consequences in the human brain. Neuroimage, 17(1), 364-372.

Voluntary action is goal-directed and therefore depends on the ability to learn associations between movements and their perceivable consequences. The neural substrate of this ability was investigated with H2(15O) positron emission tomography (PET). Healthy adults first learned that self-initiated keypresses were consistently followed by certain tones (i.e., action effects). During PET imaging, participants listened to varied ratios of action-effect

tones and neutral tones without performing any movement. The caudal supplementary motor area and the right hippocampus increased their activity with the frequency of action-effect tones, suggesting that both cortical areas play a role in linking the consequences of an action and the action itself. This integration process represents a highly flexible mechanism that helps to promote the learning, automatization, and control of voluntary

Vogt, S., Buccino, G., Wohlschläger, A. M., Canessa, N., Shah, N.J., Zilles, K., Eickhoff, S. B., Freund, H. J., Rizzolatti, G., Fink, G. R. (2007). Prefrontal involvement in imitation learning of hand actions: Effects of practice and expertise. Neuroimage. *

In this event-related fMRI study, we demonstrate the effects of a single session of practising configural hand actions (guitar chords) on cortical activations during observation, motor preparation and imitative execution. During the observation of non-practised actions, the mirror neuron system (MNS), consisting of inferior parietal and ventral premotor areas, was more strongly activated than for the practised actions. This finding indicates a strong role of the MNS in the early stages of imitation learning. In addition, the left dorsolateral prefrontal cortex (DLPFC) was selectively involved during observation and motor preparation of the non-practised chords. This finding confirms Buccino et al.'s [Buccino, G., Vogt, S., Ritzl, A., Fink, G.R., Zilles, K., Freund, H.-J., Rizzolatti, G., 2004a. Neural circuits underlying imitation learning of hand actions: an event-related fMRI study. Neuron 42, 323-334] model of imitation learning: for actions that are not yet part of the observer's motor repertoire, DLPFC engages in operations of selection and combination of existing, elementary representations in the MNS. The pattern of prefrontal activations further supports Shallice's [Shallice, T., 2004. The fractionation of supervisory control. In: Gazzaniga, M.S. (Ed.), The Cognitive Neurosciences, Third edition. MIT Press, Cambridge, MA, pp. 943-956] proposal of a dominant role of the left DLPFC in modulating lower level systems and of a dominant role of the right DLPFC in monitoring operations.

Imamizu, H., Higuchi, S., Toda, A. & Kawato M. (2007). Reorganization of brain activity for multiple internal models after short but intensive training, Cortex. 43(3), 338-349.

Internal models are neural mechanisms that can mimic the input-output properties of controlled objects. Our studies have shown that: 1) an internal model for a novel tool is acquired in the cerebellum (Imamizu et al., 2000); 2) internal models are modularly organized in the cerebellum (Imamizu et al., 2003); 3) their outputs are sent to the premotor regions after learning (Tamada et al., 1999); and 4) the prefrontal and parietal regions contribute to the blending of the outputs (Imamizu et al., 2004). Here, we investigated

changes in global neural networks resulting from the acquisition of a new internal model. Human subjects manipulated three types of rotating joystick whose cursor appeared at a position rotated 60 degrees, 110 degrees, or 160 degrees around the screen's center. In a pre-test after long-term training (5 days) for the 60 degrees and 160 degrees joysticks, brain activation was scanned during manipulation of the three joysticks. The subjects were then trained for the 110 degrees for only 25 min. In a post-test, activation was scanned using the same method as the pre-test. Comparisons of the post-test to the pre-test revealed that the volume of activation decreased in most of the regions where activation for the three rotations was observed. However, there was an increase in volume at a marginally significant level ($p < .08$) only in the inferior-lateral cerebellum and only for the 110 degrees joystick. In the cerebral cortex, activation related to 110 degrees decreased in the prefrontal and parietal regions but increased in the premotor and supplementary motor area (SMA) regions. These results can be explained by a model in which outputs of the 60 degrees and 160 degrees internal models are blended by prefrontal and parietal regions to cope with the novel 110 degrees joystick before the 25-minute training; after the acquisition within the cerebellum of an internal model for the 110 degrees, output is directly sent to the premotor and SMA regions, and activation in these regions increases.

Coombes, S. A., Cauraugh, J. H., & Janelle, C. M. (2007). Emotional state and initiating cue alter central and peripheral motor processes. Emotion, 7(2), 275-284.

Evidence indicates that voluntary and involuntary movements are altered by affective context as well as the characteristics of an initiating cue. The purpose of this study was to determine the contribution of central and peripheral mechanisms to this phenomenon. During the presentation of pleasant, unpleasant, neutral, and blank images, participants ($N = 33$) responded to auditory stimuli (startle, 107 dB startle or 80 dB tone) by initiating a bimanual isometric contraction of the wrist and finger extensor muscles. Analyses of electromyography and force measures supported the hypothesis that exposure to unpleasant images accelerates central processing times and increases the gradient of slope of peripheral movement execution. In addition, startle cues as compared with tone cues accelerated and magnified all temporal and amplitude indices. Collectively, these findings have noteworthy implications for (a) those seeking to facilitate the speed and force of voluntary movement (i.e., movement rehabilitation), (b) understanding the higher incidence of motor difficulty in individuals with affective disorders, and (c) those seeking to regulate emotional input so as to optimize the quality of intended movements.

Goldsmith, H.H., Van Hulle, C.A., Arneson, C.L., Schreiber, J.E. &

Gernsbacher, M.A. (2006). A Population-Based Twin Study of Parentally Reported Tactile and Auditory Defensiveness in Young Children. Journal of Abnormal Child Psychology, 34 (3).

Some adults and children exhibit defensive behaviors to tactile or auditory stimulation. These symptoms occur not only in subsets of children with ADHD, autism, and Fragile X syndrome, but also in the apparent absence of accompanying disorders. Relatively little research explores the correlates and antecedents of sensory defensiveness. Using a population-based sample of 1,394 toddler-aged twins, mothers reported on tactile and auditory defensiveness, temperament, and behavior problems. The incidence of defensive symptoms was widely distributed, with some accumulation of cases in the extreme range. Girls were overrepresented in the extreme tactile defensiveness group. Both auditory and tactile defensiveness were modestly associated with fearful temperament and anxiety, but they were relatively distinct from other common dimensions of childhood behavioral dysfunction. Twin correlations for the full range of scores and concordance rates for the extremes suggested moderate genetic influences, with some indication that the tactile domain might be more heritable than the auditory domain.

Cirulli, F., Berry, A., & Alleva, E. (2003). Early Disruption of the mother-infant relationship: effects on brain plasticity and implications for psychopathology.Neuroscience and Biobehavioral Reviews, 27, 73-82.

This review paper examines the hypothesis that early environmental changes in the infant-mother relationship may lead to greater vulnerability to age related changes in brain function and also psychopathology. The paper reviews 95 different studies (primarily of non-human mammals) that support the following: First, that mothers regulate infant states and arousal levels and that maternal stimulation (including primarily tactile stimulation) affects the infant's developing brain. Second, that interruptions of the mother-infant relationship via separations or laboratory manipulations can cause long term effects in the endocrine system in particular (changes in receptors and neurons involved in the stress response). In addition, these manipulations can affect brain plasticity via changes in long term potentiation, neurotransmitter activity and hypothalamic-pituitary-adrenal responses. Third, there is evidence to suggest that environmental stimulation can compensate in some part for early adversity. Fourth, that changes and manipulations of mother-infant relationships alter the mother's behavior as well. Fifth, that neurotrophins are crucial for brain development and plasticity, and that external stimuli can affect neurotrophin levels. Sixth, that manipulation of mother-infant relationships, in particular maternal –infant separations, can affect neurotrophins. Lastly, that early experiences in the maternal-infant relationship can therefore have long term effects on the brain through changes in neural plasticity.

Nietro-Sampedro, M. & Nieto-Diaz, M. (2005). Neural Plasticity: Changes with Age. Journal of Neural Transmission, 112, 3-27.

This paper provides a lengthy review of decades of research that examines the now well established fact that the brain is plastic and can change throughout our lifespan. The stimuli that lead to plasticity include lesions, physiological changes, environmental needs or challenges and experience. This paper suggests that neural plasticity is really synaptic plasticity and that learning, memory, and responses to our physiological needs all occur via synaptic and neural plasticity. These functions change with age however. In early life there is developmental synaptogenisis which slows to a level of synaptic renewal or maintenance in adults. The stimulus for this synaptic renewal in mammals is typical stimuli that induces learning or requires memory. It is suggested that this occurs via long term potentiation. Long term potentiation is related to a process described by Hebb whereby a synapse that is repeatedly used is reinforced, needing less intensity of stimulation to fire in the future or firing with greater intensity to the same stimulus. An opposite phenomenon has also been observed. Long term depression occurs when a synapse is stimulated over prolonged periods. This reverses long term potentiation. Research has also shown that LTP is related to changes in dendritic spine formation and also to age related deficits in memory, particularly in the hippocampus. There are also age related changes in axon spouting and in nerve growth factors.

Schmidt, L.A. & Fox, N.A. (1998). Fear-potentiated startle responses in temperamentally different human infants. Developmental Psychobiology, 32, 113-20.

Researchers examined the startle responses of infants in relation to their temperament styles. They theorize that fear responses to novel stimuli may be related to a low threshold for arousal in the amygdala and central nucleus of the forebrain. These early fear responses have been shown to be related to behavioral inhibition in toddler-hood. Previous research has suggested that it is the connections between the limbic system and the frontal cortex that regulate the negative behaviors and avoidance common in inhibited children. This study examined a group of 73 infants at 9 months of age who were chosen out of 243 for their reactions to novel auditory and visual stimuli at 4 months of age. Their startle eye blink responses were recorded via EMG under two conditions, one baseline and one novel and potentially fear producing. The researchers predicted that infants who at 4 months had a high frequency of negative affect to novel stimuli would have a greater startle response at 9 months of age. What they found was that although both groups of infants were equal at the baseline condition in terms of their startle responses, in the group of infants who showed negative affect at 4 months,

there was a greater increase in startle between the baseline condition and the novel condition. The researchers suggest that there are biological predispositions for reactions to novelty and that some children may be predisposed to fear and anxiety responses.

SIGN note : Are these predisposed children the ones with sensory defensiveness????

Piek, J.P., Dyck, M.J., Nieman, A., Anderson, M., Hay, D., Smith, L.M., McCoy, M., & Hallmayer, J. (2004). The relationship between motor coordination, executive functioning and attention in school aged children. Archives of Clinical Neuropsychology, 19, 1063-1076.

This paper explores relationships between the diagnoses of developmental coordination disorder (DCD), attention deficit disorder (ADHD) and abilities in executive functioning (EF). Two groups of children completed EF tasks that typically distinguish children with and without ADHD. The first group had typical motor coordination and the 2 nd group had DCD. The authors predicted a relationship between coordination, attention and executive function. The sample included 238 children in Australia with a mean age of 10.58 years. They all had a verbal IQ above 80 and the mean IQ score was 102. Of this sample, 28 of the children met the criteria for DCD. The results demonstrated a weak link between attention and executive functioning tasks and also between motor coordination and executive functioning tasks. Strong associations were found between attention and motor coordination. The authors therefore suggest that previous research showing a relationship between DCD and EF may have been because of co morbid ADHD.

Bernabei, P., Fenton, G., Fabrizi, A., Camaoioni, L., & Perucchini, P. (2003). Profiles of sensorimotor development in children with autism and with developmental delay. Perceptual & Motor Skills, 96, 1107-1116.

Pre-school aged developmentally delayed children with(n=46) and without (n= 45) autism were compared on the Uzgiris-Hunt Scales which examine abilities such as object permanence, means-ends relations, imitation, causality, spatial relations and schemes of relating to objects. The children with developmental delays but no autism showed a fairly homogenous performance on the tool, with high correlations among the scale scores. They appeared to be evenly delayed in all areas. The children with autism on the other hand showed more uneven performance with specific difficulties in the imitation items, both verbal and gestural, and also with schemes for relating to objects.

SIGN note : imitation difficulties may indicate dyspraxia in this population. It has been hypothesized that dyspraxia may be at the route of some of the difficulties experienced by children with autism.

Reynolds, S. & Lane, S.J. (2007). Diagnostic Validity of Sensory Over-Responsivity: A Review of the Literature and Case Reports. Journal of Autism and Developmental Disorders- Online Oct.

Atypical responses to sensory stimulation are frequently reported to co-occur with diagnoses such as autism, ADHD, and Fragile-X syndrome. It has also been suggested that children and adults may present with atypical sensory responses while failing to meet the criteria for other medical or psychological diagnoses. This may be particularly true for individuals with over-responsivity to sensation. This article reviews the literature related to sensory over-responsivity and presents three pediatric cases that present a profile of having sensory over-responsivity without a co-occurring diagnosis. Findings from these cases provide very preliminary evidence to support the suggestion that sensory over-responsivity can occur as a sole diagnosis. Within this small group, tactile over-responsivity was the most common and pervasive form of this condition.