Why multisensory integrative therapy should be successful in addressing problems across a broad spectrum associated with developmental delays.

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This paper examines the reasons why multisensory integration is thought to develop, and what research has been done to justify proposed models of this development. This forms a logical backdrop to analyze anecdotal evidence that multisensory integration therapy is effective in resolving a wide spectrum of developmental delays and neurological (software) disorders. Some kinds of sensory integration therapy have been shown to have beneficial effects over extended periods of time, when administered by occupational, physical, psychological, speech and vision therapists. Other kinds of therapy, such as the Sensory Learning Program devised by Mary Bolles, have been shown to have beneficial and lasting effects in 30 days or less. Irrespective of the time it takes to achieve these results, a rationale and a scientific explanation are called for to determine what the therapy does to alter brain structure, function and behavior in a positive manner. Also salient is that this same type of therapy proves effective irrespective of the age of the client, and across a wide spectrum of chronic developmental delays, brain injury, and behavioral disorders.

Sensory integration therapy is expected to accelerate the time taken to develop expected milestones that are manifestly delayed. The effectiveness of treatment is dependent, therefore, on what structures, functions and behaviors are already developed and in place, and can be adjusted and built upon to produce healthy development.

Of critical importance in understanding normal development and developmental delays is an appreciation of what are known as inner perceptual systems that drive structural, functional and behavioral processes. The key to this is the inbuilt life driving forces that combine their inner and outer energy sources in the processes of maturation, experience, communicating transmission and self-regulation.

Human beings with their 23 pairs of chromosomes inherit some 40,000 genes from 4 bases that provide the proteins and 20 amino acids that constitute the building material and the building blocks to create our molecular makeup. Every molecule has its own energy potential and ability to trap energy to carry out its specific function. The energy required for this process comes from the elements, oxygen, water, and food, and from sunlight and other electromagnetic radiation to provide for cellular work and chemical synthesis.

Outer and inner forces, in combination, operate to provide for self-assembly, self replication and are subject to life sustaining forms that are fit to survive. The human organism relies on the external physical environment to develop the brain and body's sensory and motor systems and the organs and mechanisms for breathing, blood and other circulation, filtration, and for digestion.

The major driving forces that are essential for brain development and function depend on oxygen and glucose metabolism, the melody that comes from movement (vestibular balanced orientation),

and on electromagnetic energy in the forms of light and sound. Together they constitute the most powerful and effective mechanisms to develop the brain and its numerous connections.

The external environment is in a state of constant movement, as are all living forms within it. But for movement to be purposeful it requires gravitational anchoring, balance and direction. Gibson (1966) who wrote "The senses considered as perceptual systems", considers the *basic orienting system* to be the prime sense. It is only when the sensory receptors, *taste/smell, haptic/kinesthetic, auditory* and *visual* are oriented correctly that they are able separately, and in combination, to answer the perceptual questions of who? what? where? when? how? and why?

A. Jean Ayres, the doyenne of occupational therapy recognized the power of multisensory integration and the role of the vestibular system, particularly in treating sensory and motor problems. Extensions of her philosophy form the basis and rationale for the way occupational therapy is practiced today. Ayres (1979) proposed that learning and other developmental disabilities could be resolved by revisiting the developmental process of integrating information from the senses into an organized whole (Carte, Morrison, Sublett, Demura, & Setrakian, 1984; Kranowitz, Sz1ut, Balzer-Martin, Haber & Sava, 2001).

The American Occupational Therapy Association, 1997, and Case-Smith and Byron, 1999, hold that SI therapy seems a logical approach to address some of the broad spectrum of sensory and motor problems that manifest in autism and other learning disabilities. Now SI therapy is being applied to children with autism, developmental dyspraxia, ADD/ADHD, nonverbal learning disabilities, general motor clumsiness and environmental sensitivities, and mental retardation. The power of such interventions is corroborated by Stein, Jung and Stanford (2004) who show the multiplicative effects in brain responses through the integration of visual, auditory and somatosensory information.

There is increasing evidence that sensory integration is a normal central nervous system (CNS) developmental process that organizes sensory and motor feedback and feedforward in order to make appropriate adaptive responses (Ermer & Dunn, 1998). The neuroscientific findings that support this rationale confirm the plasticity of the CNS throughout life, the development of sensory integration that occurs in a sequential predictive way, the changes that occur in a nonsequential way as the result of different individual learning experiences and environments, and lastly factors of physical, psychological and emotional maturity and potential that affect an individual's motivation and self control. All of these factors are believed to influence a basic inner drive to integrate information (Bundy, Lane, Fisher & Murray, 2002).

The placebo effect has been found to influence the outcome of experiments where subjects are told to expect a positive or negative result in a cross-over controlled experiment. We now have imaging studies of brains that show evidence of these - effects, and that correlate with psychometric measurements (Holden, 2002; Petrovic, Kalso, Petersson, and Ingvar, 2002).

We all know that SI therapy does not occur in a vacuum, but that it involves faith-based support and an atmosphere that is calm and stress-free for both caregivers· and the individual receiving treatment. It is only when individuals feel unthreatened and has minimal apprehension that they become receptive to treatment. It is on the basis of perceived results that these individuals expose themselves to structural, functional and behavioral changes.

Stein, Jiang and Stanford (2004) discuss the principles guiding the integration of visual, auditory and somatosensory information. The somatosensory modalities embrace discriminative touch, sensitivity to pain and temperature, and proprioception-information coming from stresses and forces on muscles, tendons and joints. Stein et al. conclude that there is a growing awareness that the brain engages in an ongoing synthesis of informational streams that travel along different sensory channels. This is based on compelling evidence that the visual, auditory, somatosensory, vestibular, olfactory, and taste senses are all highly influenced by each other. These authors also cite the research of Hartline, Kass and Loop (1978) that shows that pit vipers possess an infrared system used for detecting other animals' heat signatures.

There is almost nothing in the medical literature to examine the effects of the electromagnetic spectrum (invisible radiation as well as the visible light spectrum and the audible sound spectrum) on the inner workings of the brain and their effects on multisensory processes. However, medicine has treated neonatal jaundice effectively with phototherapy for more than a half century, and introduced radiation therapy for ca11cers since the beginning of the twentieth century. It has also recognized the importance of sunlight/vitamin D in preventing rickets, and in promoting normal bone growth. Today, integrative Western medicine is beginning to study and apply the effects of subtle energy fields as an important part of treatment across a wide spectrum of dysfunctions.

Yale professor Harold Saxton Burr conducted studies .more than 50 years ago linking body function and energy fields produced within and around the body. The magnetic sense and the electromagnetic sense are ways living organisms respond without using the usual sensory information. These energy fields connect the biophysical and molecular mechanisms of the person to environmental rhythms.

An analysis of the Sensory Learning Program developed by Mary Bolles in 1990 consists of a combination of diffuse color changing light stimulation and gated music. This light and sound stimulation is carried out while the client is lying in the supine position on a motion table crossing the horizontal midline and the vertical midline on alternate days. This routine is carried out twice daily, once in the morning and once in the afternoon for a period of 30 minutes per session, for twelve consecutive days. When the twelve day sessions are completed, the client is given a light box to take home to continue to receive the color light stimulation for a further period of 18 days on awakening in the morning and immediately before going to bed in the evening. This completes the thirty day intervention.

The effectiveness of Mary Bolles' Sensory program?- lies in what Malcolm Brown, a cell biologist describes as "a front-end approach to initiate nerve regrowth and brain remodeling that allows the body's important chemistry to become autocatalytic" (Brown, May 2004).

Bolles has initiated a study to determine why her specific intervention (combining vestibular, visual and auditory stimulation firstly, and then followed by visual light stimulation) should work the way it does, and for which she has accumulated an abundance of anecdotal evidence of the success of these procedures.

A vital facet of human function and behavior is the need to relate to the outside environment and to other human beings in a meaningful way. In essence this is the need to answer the key questions of who/what, where, when, why and how we experience ourselves and the outside world. This is what

the senses do perceptually in combining their inputs to derive the most accurate information and for most effective action. Perception can therefore be seen to be a multisensory phenomenon where our senses are designed to act in concert. Our brains are organized to use the information so derived from the various sensory channels cooperatively. In this way we can react and respond appropriately and timeously to objects and events.

Researchers now recognize that our everyday environment engenders a constant influx of sensory information in most of the sensory pathways (Calvert, Spence & Stein, 2004:iv). The brain's task here is to sort through a multitude of sensory bombardments selectively and to absorb only that to which it decides to respond. This brain activity is against a backdrop of sensory signals that need to be kept separate to determine different perceptual events.

Whereas much progress was made in studying the senses separately, there is now an urgent impetus to study the implications of multisensory integration and multisensory processing. Historically, it would seem that occupational therapists have led the field in order to fulfill the multisensory integration and processing needs of their clients in their activities of daily living. It now rests with the scientists to provide the empirical evidence to show why sensory integration works to alter aspects of structure, function and behavior.

The scientific enquiry thus started has determined data that suggest remarkable consistencies in the way the brain synthesizes the different sensory inputs in very different ecological settings, and irrespective of what senses combine. Thus it will be found that spatial information that comes from visual and auditory inputs are found to result also from chemical taste and smell receptors (Dalton, Doolittle, Nagata & Breslin, 2000). Perhaps, of more interest and relevance from a clinical perspective are the sensory signals that are critical for social interaction and relating individuals consciously and appropriately to other individuals (Hughes, 1998; Partan & Marler, 2000). Dysfunctions in this area appear to relate to the communication and social interaction problems experienced in autism.

A major clinical concern that embraces sensory integration, modulation and discrimination, is how the brain reacts to conflicting signals that might cause confusion, disruption and disorientation (Rock & Victor, 1964; Welch & Warren, 1980). It would seem here to affect individuals by virtue of faulty reticular arousal and inhibition mechanisms.

When we observe human beings who are functioning normally, we assume that the different parts of the brain that process sensory information separately, by virtue of their development and sensory experience, are able to coordinate their different reference schemes regardless of their modality inputs. The task is to find what helps to build and repair dysfunctional brain systems so as to make their sensory and motor functions operate together synergistically and normally.

Occupational therapists believe that for therapy to be effective, clients have to be engaged in purposeful activity. There is no question that *conscious attention* when it is directed in a topdown executive controlling fashion will impact on the structures, functions and behaviors that affect

learning. In fact this is supported by the theoretical model conceived by Luria and La Yudovich in their work on Speech and the Development of the Mental Processes in the Child (1968). These authors postulate that the environment is the best teacher; but formal teaching is of value because it helps to identify and explain the details necessary to understand and master a subject; builds and extends necessary functional sequences; and lastly accelerates the processes of learning.

However, the key here is that purposeful activity in formal learning and training requires active participation on the part of the teacher/therapist and the learner/client. How, then, can one resolve the issue of the effects of *passive* as opposed to *active* occupational and other functional and behavioral interventions? Part of the answer would seem to be explained by Fantz, who states that *perception is innate in the neonate, and largely learned in the adult.* Another part to the answer can be derived from Piaget's model of intellectual development which builds on the sequential steps of *maturity, experience, social transmission* and *self-regulation.*

We should be careful not to define *neonate* and *adult* too narrowly in these contexts, but to understand that the two tends lie on a continuum that describe the anatomical, physiological and psychological emotional maturity of the individual that develop from inability to self-regulate to the ability to self-regulate these functions.

The developing child relies on reflex responses to outside stimulation over which self-regulation has not yet developed. It is this stimulation that connects and integrates the different parts of the brain as a prerequisite to the communication that relates self to the outside world. This reflex learning is necessary and vital in the healthy development of human structures, functions and behaviors.

The essence of the Sensory Learning Program lies in the non motoric participation of the client who, in a relaxed alpha wave state, is not called upon to focus consciously on focused or detailed informational inputs .. At this level, diffuse stimulation can act on those parts of the somatosensory brain with raw sensory data, without engaging the frontal lobes that seek to obtain and process cognitive inputs. Bolles believes the Sensory Learning Program facilitates convergence in the superior and inferior colliculi to advance multisensory processing and sensory modulation, sensory-based motor, and sensory discrimination, which might otherwise be channeled through the occipital visual or temporal auditory cortex to process detailed and discrete stimuli. The separate sensory stimuli work together, Bolles believes, by entraining the vestibular system with motion, stimulating the ocular system with colored frequencies of visible light which changes the firing pattern of the hypothalamus, and exercising the auditory system through gated music, instrumental and vocal, which allows the stirrup to change its monitoring position against the oval window as the participant's attention shifts from point to point.

Because multisensory integration appears to rely on orientation mechanisms it serves a useful

purpose to examine the research that backs this model of thinking. Much of this research has been done on nonhuman primates. Van Opstal and Munoz show how integration of auditory and visual information affects individual neuron speed shifts of gaze that facilitate the localization of external events. Diederich and Colonius show how this affects manual and eye control in this context, while Lackner and DiZio show the utility of multisensory integration where body orientation and movement must be controlled. Because each sensory modality uses a different coordinate system to represent space, the brain, according to Cohen and Anderson, has to find an efficient way of interrelating these schemes in order to use cross-modal cues cooperatively.

The introduction of human brain studies of multisensory processes together with psychometric measures has now given researchers powerful tools to relate structure to function and behavior. Electroencephalographic, functional magnetic imaging and positron emission tomography when combined with even newer techniques provide for qualitative as well as quantitative data of great value to determine treatment and its results.

We now have better tools to examine the data of clinical studies and assess exactly what breaks down in multisensory integration processes that lead to conditions such as autism, *ADD/ADHD,* speech delays and other pervasive developmental disorders. We can also compare different models of treatment and their applications. With this knowledge we should be able to be more receptive to new ideas and treatments.

In good faith as scientists we should respect real life powerful anecdotal evidence as being authentic, and develop our research studies to prove or disprove their hypotheses. Over a century ago, Hugo Munsterberg said "Our time longs for a new synthesis-it waits for science to satisfy our higher needs for a-view of the world that shall give unity to our scattered experience." One hundred years later, the new synthesis is on the horizon.

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