

Understanding Behaviors

By Margot Schmiedge

On November 5, 2007 I attended a conference given by Kim Barthel. Kim is an occupational therapist with extensive post-graduate studies in neurobiology, sensory integration, and numerous other therapies. She has a rare gift of knowledge, patience, and ability to look at a child as a whole. As luck would have it, we lived only six hours from her treatment center when our daughter was young. Kim taught us to carry through with the therapies ourselves.

In this conference, Becoming a Behavioral Detective, Kim hoped to teach us to observe our children's body language and to better understand what processes are simultaneously happening in the brain. She did not promise earth-shattering intervention, but she hoped we would better understand the reasons for the behaviors.

I attended the conference because we have an eighteen year old daughter with Kabuki syndrome. She has also been diagnosed with autism. I do not believe that, coincidentally, she has two different syndromes. Many, if not most children with Kabuki have autistic-type behaviors. The word 'autism' is simply a name given to describe a sensory processing disorder. Many children with various genetic syndromes have sensory processing disorder as part of their syndrome. Therefore, to prevent confusion, I have used the term 'sensory processing disorder', while Kim, for simplicity's sake, has often used the term 'autism'. They are one and the same.

The following is based on my notes from Kim's conference, interspersed with a few explanations from my own research.

Understanding behaviors requires a balance of knowledge and insight. Even the behaviors of typical children have purpose and therefore meaning. Many of us are still influenced by old-school thinking that when children behave in inappropriate ways, they are being naughty and need punishment. We are only beginning to question what the behavior is providing for the child. Why are they choosing that behavior? What need is it fulfilling? Is the behavior necessarily undesirable? Is it possible to assist the child so there is less need for the undesirable behavior? These are the questions we hope to better understand as we become behavioral detectives.

Behavior is an observable response to an internal feeling or an outside event. It is a communication clue. The age-old debate of whether behavior is genetically or environmentally determined is exactly that, age-old. It is well accepted that both genetics and environment are contributing factors. As an example, one of the 'shyness' genes has recently been discovered. Certain genes will only express themselves if the environment support them, and will stay 'dormant' if the environment does not. So in the case of the shyness gene, if the environment encourages self-expression and positive self-esteem, the gene is less likely to express itself.

Explosion of info

In the last ten years there has been an explosion of understanding of the brain and its bio-neurological processes. Autism (or sensory processing disorder) has been one of the major contributors. Coupled with the advanced brain-imaging technology we now have at our disposal, scientists are making new discoveries at alarming rates. Positron Emitting Topography (PET scans), Functional MRI's, EEGs, and numerous dyes all help to measure physical processes in the brain.

It has been discovered that cells can learn. We used to think that the cell's nucleus was the 'brain' of the cell. We now know that it is actually the membrane. The membrane decides what it will allow inside the cell. The receptor sites on the membrane surface can be influenced to let substances enter that the cell may not have originally been designed to do. Some cells are more easily 'convinced' to allow this change, and when they do, these foreign substances can actually change the DNA of the cell. If the DNA has been altered, the cell will have a 'memory' of the change and will transfer to the next generation. In other

words, environmental influences on our ancestors' cells have a direct effect on our genes. In essence, we are describing evolution. *Our environment* (our stresses, what we eat and breathe) *has a direct effect on how our neuro-system develops.*

The human brain has about 100 billion neurons which receive, process and transmit information. In between neurons is a space which is called a synapse. A variety of substances in this synapse area, including neurotransmitters, influence how the neuron behaves and how well the information is passed from one neuron to another. It is believed that each neuron can have upward of one hundred thousand synapses. At birth there are relatively low amounts of synapses in the brain. In other words, the neurons have not yet made connections with one another. In the first three years of life, there is an astonishing amount of synapse growth. In fact, for the rest of the first decade, a child's brain has twice as many synapses (connections from one neuron to another) as that of an adult. The most prolific 'pruning' of the neuron synapses occurs during the puberty years, in particular of the cerebral cortex (the thinking part of the brain). This could explain a few things about our teens! In other words, learning is not only about creating new connections between neurons, but it also involves carving neuronal connections. This fact has inspired the writing of various books further describing how teens need increased structure and guidance as they adapt to their 'new' brain.

When we first learn to tie our shoelaces, we cannot also carry on a conversation about, say, what we did that day. The pathways from neuron to neuron are still not refined for that particular activity. As the thousands of connections are made (the thinking part, the motor parts, etc) and the neurotransmitters and other chemical processes are perfectly refined, the act can then be done with more and more ease, until the day it could even be performed while calculating a complicated math problem. Such is the art of learning – there are actual physical processes happening in the brain to allow learning to happen. In other words, learning causes structural changes in the brain's anatomy.

Research has shown that there is an increased amount of neuronal growth for particular sensory experiences in the individual with sensory processing disorder. The brain says, "That feels good, I like that, let's do that more often," which then, in turn, increases the growth of those particular neurons and their synapses.

As often happens with new discoveries and understanding, Kim felt that, in the future, what we now clump together and call 'autism' will very likely be labelled with a sliding scale of sensory processing dysfunction, more accurately describing the physical happenings. Kim stressed, however, that this conference does not propose to speculate the causes of autism. She strongly felt that there are many contributing factors for the increased amount of children we are seeing with sensory processing difficulties, but that we still need to do much more research to discover what physical processes happen in a 'healthy' bio-neurological brain versus one that is malfunctioning at some level.

Dr. Jean Ayres, credited with first having identified sensory integration dysfunction, thought with the proper therapy a child's academic performance could be altered. Certainly, acquiring optimal sensory equilibrium enables learning to take place. Kim likes to think of therapy as "sensory processing intervention" – therapy which *participates* in the individual's journey of life with a disability.

Arousal levels

To learn, the brain needs to be in an optimal state of arousal. **There are three things that contribute to arousal – sensation, cognition, and emotion.** All three are constantly interfacing with one another.

Sensation includes the input from our senses – eyes, ears, skin, mouth, and smell. Children are naturally sensory seeking. Ideally, our brain takes in the sensations, processes and makes sense of the information and then produces an appropriate response. The brain NEEDS sensory input. When we change position or fidget with our hands while sitting at a conference, it is not to simply increase our circulation. Our brain needs constant sensory input. It is 'food' for the brain. One only has to look at past real-life experiences and experiments of sensory deprivation to know the detrimental effects it can have on the brain.

Cognition is the thinking contribution we make to our state of arousal. It can increase or decrease levels of

arousal. Individuals with sensory processing disorder have given us further insight to the importance of this factor. Dr. Temple Grandin, a well-known individual with autism, has explained that when she enters a room, she is bombarded with sensory input – the lighting, the pictures on the wall, the placement of the furniture, the hum of the air conditioner, and on and on. She must use her cognition to lower her arousal level. To do so, she tells herself that she has been in similar rooms in the past and she does not need to pay attention to the sounds or decor. In this way, she is then able to pay attention to what is important. Of course, it is an extremely exhausting process.

Emotion is the third contributor to our state of arousal. Various neurotransmitters are produced by specific parts of the brain, and we now know that they are very important contributors to our emotions. To be overly simple: if dopamine is altered, a person may be out of touch with reality; if norepinephrine is altered, a person may be manic; if GABA is altered, one may be anxious, and so on. A person with depression will have a low state of arousal, while a person with anxiety will have a high state of arousal.

For learning to take place, our level of arousal should be somewhere in the middle. Often, individuals attempt to regulate themselves, as with the example of Dr. Grandin. We have an innate desire for equilibrium. Regulation is defined as an internal process of adjustment that ensures order and accuracy in physiological responses to the environment.

Kim gave some very dramatic examples from her own experiences. Although she likely has many more subtle ones, she said it is the dramatic examples that help her remember the vital importance of how these three contributing factors are constantly interfacing with one another.

Kim relayed that she was asked to treat a boy from Winnipeg who had lived on the streets. He was in a state of high arousal or hyper-alertness, a state he needed to be in to survive on the streets. Kim spent some time with him, lowering his state of arousal. Forty five minutes after leaving him, he tried to commit suicide. While in his high state of arousal, his attention was unfocused. Once his level was slightly lowered he was able to focus and use his cognition to attempt suicide. Emotions, cognition, and sensory are all very intertwined and co-dependent on one another. This particular example illustrates the importance of treating the emotional aspects once arousal levels have been altered.

Sensory system

Because an individual's state of arousal is so intrinsic to learning, Kim further explored the sensory system. The sensory system involves three key areas - the senses (smell, tactile, etc), proprioception (our body's positional awareness), and the vestibular (dominant provider of movement and balance).

Visual - It is thought that eighty-seven percent of our sensory input is directed by vision. It is especially important in our ability to process movement. An example Kim provided was the poor posture of a blind boy she was treating. It was believed he had poor muscle tone, when in reality, his lack of vision failed to tell him how to carry his body.

Our senses consist of a 'primal' or 'survival' level and a more refined level. Ambient vision is our peripheral vision which, primarily, provides us with spatial orientation. It is designed for survival. Focal vision, or central vision, allows us to zoom in on detail. *Whenever systems are compromised, such as a person with a high arousal state, the survival mode will take prevalence.* This is important to remember when asking children with high anxiety levels to look us in the eye. They will be able to listen better if we allow them to use their ambient vision. Ambient vision gets priority for most children with sensory processing disorders.

Auditory – Sound vibrations enter the ear, eventually integrating information along the auditory pathways through the brain stem. The sound is 'heard' but not yet deciphered since the brain stem does not discriminate distinct sounds. Eventually sounds pass along a myriad of neural pathways to various parts of the brain discriminating whether it is a human voice or birds chirping. Further discrimination is then needed to determine what the voice is saying or what type of bird it is. Many individuals with sensory processing disorders are attuned to sound, but are less able to discriminate what those sounds mean. Again, survival mode of processing takes precedence.

Tactile – The tactile system allows us to discriminate our environment. The entire body has tactile receptors. There are numerous types of receptors, most notably, pain, temperature, and touch. Light touch increases arousal levels while deep pressure decreases arousal levels. Think of lying on the beach with your eyes closed when someone strokes your back very lightly with a feather. Immediately, you jump up and become completely alert to the sensation. You may even become angry. Your arousal level has been greatly heightened. Now think of receiving a deep muscle massage and how easily you could fall asleep from such an experience. Your arousal level has been lowered.

Smell and Taste – The mouth has the most sensory receptors in the body. Taste is conveyed to the brain via three of the twelve cranial nerves. Sensitivity to taste is distributed across the entire tongue, even the epiglottis and soft palate. It is believed that chewing objects, aside from providing self-stimulation and therefore soothing effects, may also provide the benefit of enhanced vision by stimulating the optic nerve which runs along the upper palate.

The nose is the only organ that is an extension of the brain. The sense of smell has a close connection with the autonomic system and can therefore produce very strong reactions (fight or flight). Information also travels to the limbic system – a primitive brain structure that governs emotions, behaviors, and memory storage.

It is interesting to note that most self-soothing behaviors involve midline structures of the body which contain the most sensory receptors - oral, smells, masturbation.

Proprioception – Proprioception is the process by which the body can vary muscle contractions in response to incoming information. It is developed by the nervous system as a way to keep track of and control the different parts of the body. A person with good proprioception will be able to feel in what position their legs are, even if they are hidden from view. Without it, the brain must constantly visually check where the body parts are and consciously will the muscles to move when necessary. Very tiring and distracting!

Vestibular – The vestibular system controls the sense of movement and balance. It lets us know whether we are moving or whether the room is. It is the system that most influences the other sensory systems. Dysfunction of the vestibular system can cause anxiety, abnormalities in muscle tone, a need for self – stimulation activities, difficulty defecating, academic problems, and more. Vision is an important part of the vestibular system since about twenty percent of visual neurons respond to vestibular stimulation. The auditory system is also highly involved, especially the inner ear. The vestibular and auditory nerves join in the auditory canal and become the eighth cranial nerve in the brain. The vestibular system coordinates information from the inner ear, eyes, muscles and joints, fingertips and palms of hands, pressure on the soles of feet, jaw, and gravity receptors on the skin. It adjusts heart rate, blood pressure, muscle tone, limb position, immune responses, arousal levels, and balance.

Children under the age of twelve depend largely on their sensory system. As they mature, they gain a greater ability to use their cognition to override the sensory system. Think again of Dr. Grandin's description of needing to use her cognition to overcome the sensory overload.

It is important to think of the state of arousal of an individual when requiring high levels of attentiveness. Think of the situation of having a feather stroked along your back or hearing a threatening sound in a dark alley. Adrenaline is pumped throughout your body. Your heart rate, blood pressure, and pulse have all increased. Imagine now that while in this state, someone is trying to teach you an algebra equation. It is almost ludicrous to think your brain could handle such a thing. You are in a fight or flight situation, and safety, or survival, will dominate and take precedence, even if it is only perceived danger. For the individual with a sensory processing disorder who spends a lot of time in this fight or flight state, learning becomes very difficult!

Sensory processing

There are four levels of sensory integration, each level building upon the previous level. For most of us, this happens very naturally in infancy and childhood. All the playing, climbing, yelling, etc of children are unconscious methods used to 'feed' the brain and allow integration to occur. However, for those with sensory processing disorder, entire levels or parts of levels do not become adequately processed or

integrated – for whatever reason. It is with this insight, and patience to observe behaviors, that we (parents, therapists, and teachers) hope to assist the child in achieving the greatest equilibrium. Kim felt that it is important not to think of achieving greater sensory integration as simply a ‘therapy’ that can only be administered by a therapist. It is a life-long goal to which we should all contribute.

Please see the table below which recaps the building blocks needed to attain the ultimate goal of academic readiness.

The Four Levels of Sensory Integration

Academic skills Complex motor skills Regulation of attention Organized behavior Specialization of body and brain Visualization Self-esteem & self-control	Academic Readiness
Auditory perception Visual perception Eye-hand coordination (pencil skills) Visual motor integration Purposeful activity	Perceptual Motor Skills
Body percept (body awareness) Bilateral coordination (teamed use of both sides of body) Lateralization (hand preference) Motor planning (praxis)	Perceptual-Motor Foundations
Tactile sense (touch) Vestibular sense (balance & movement) Proprioceptive sense (body position) (Visual and auditory senses)	Primary Sensory Systems

Sensory Processing Challenges

We all have our own unique sensory thresholds – the minimum amount of stimulus needed to elicit a sensory response. Individuals with sensory processing disorders usually have either a high or low threshold for a particular stimulus. That does not mean that just because they have a low threshold for, say, tactile, they cannot have a high threshold for, say, vestibular. When faced with imbalance, we naturally try to attain a sense of equilibrium. We look for ways to either up-regulate or down-regulate to find that optimum level of arousal.

Low threshold – Individuals with a low threshold have an increased sensitivity to a particular stimulus. They are hyperreactive to the stimulus (note that it does not say ‘hyperactive’), and in attempt to counteract it, they avoid the stimulus. Usually, the behavior of the individual makes it clear as to what they are attempting to avoid. Sometimes, however, we need to be detectives. Kim gave an example of a young Rawandan girl that had immigrated to Canada with her family. She had spent a number of years as a prisoner in a war camp. During therapy, she was in constant motion. The initial quick assessment would have suggested that she had a high threshold and was ‘seeking’ sensory stimulus. However, upon further evaluation, it became evident that she was in constant movement to avoid sensory experiences (likely due to conditions in the camp). Her movement was an attempt to escape any form of physical contact. In other words, she had a low threshold to sensory touch. So it is important to evaluate whether the behavior is an attempt to ‘feed’ a need (high threshold) or avoid an aversion (low threshold).

High threshold – Individuals with a high threshold need more stimulation than average to process the sensation. Frequently these individuals seek sensory stimulation. They are hyporeactive to stimulus

(again, not 'hypoactive'). It is as if their nervous system contains 'holes' and normal activity simply does not meet the requirements of feeding the brain. Remember, our unconscious movements during times of attention are not simply for circulation purposes. The brain 'tells' us it needs sensation if we want it to continue to pay attention. Thankfully it is done at an unconscious level for most of us! As is with individuals with low thresholds, those with high thresholds can use either an active or passive strategy to help themselves modulate. They may choose to be in perpetual movement to 'feed' a need or hang on their desks since the need is not being fulfilled.

We are learning many new terms that are sometimes difficult to apply to real-life situations. Although behavior is never a clear-cut issue, let's recap:

Low threshold means the individual is hyperreactive and therefore has an increased sensitivity to a stimulus. They typically have a high level of arousal.

They are typically easily overwhelmed by sensory input. They often actively avoid sensory input, thereby modulating their own arousal level. Their attention is unfocused but can be hypervigilant for a certain task. They are unable to screen out irrelevant input. Every experience is novel, which increases arousal level since there is no constancy. They can be fearful, anxious or negative and their actions are often defensive or protective in nature. They may appear impulsive.

High threshold means the individual is hyporeactive and therefore needs a lot of sensory input before responding. They have a low level of arousal. They often appear uninterested and are slow to take action. Because their body does not orientate towards you, it may appear as though they are ignoring you. They may seek sensory stimulation to increase their arousal level, but it tends to have inconsistent results. They may become overly aroused and easily pass into a state of disorganization. Their attention is poorly modulated.

Modulation

When faced with a stress, real or perceived (and if it is perceived, it actually becomes real), our internal system appraises the situation and concludes that something important is happening here and now! Our nervous system focuses our energy on attention and perception, which then prepares us for action. Modulation means we can adjust the intensity of an incoming stimulus – turn the volume up or down. It allows the nervous system to move easily and quickly from stressing to coping.

Remember the levels of sensory integration – each level is a building block for the next level above it. Individuals and/or therapists often provide sensory input (lower level) so that learning (higher levels) can take place. However, as we discovered from Dr. Temple Grandin and many others with sensory processing disorders, arousal levels can also be influenced from an upper level (cognition) to create self-control or equilibrium. In other words, arousal regulation can come from cognitive (upper levels), not just sensory (lower levels).

To further understand this, we need to look at some important structures of the brain and how they affect arousal levels. Over the millions of years, man's brain has evolved, presumably an adaptive response to environment, diet, and other stresses. The size of the brain has increased. The position and size of brain lobes have also changed. Some structures such as the cerebral cortex (the thinking part of the brain) were only present in a rudimentary form in earlier man.

Reticular formation – The reticular formation is a very old and primitive part of the brain and is situated in the core of the brain stem. Without getting too technical (just do a google search on any of these structures and you will understand!), the reticular formation is an area of the brain that receives information from most of our sensory systems and sends it on to other parts of our nervous system. It does not discriminate the information. It is instrumental in our arousal states in that it influences our level of consciousness and 'awakeness'.

The reticular formation is sensitive to two neurotransmitters - adrenaline and serotonin. Adrenalin causes the reticular formation to activate arousal. Remember, the reticular formation does not discriminate different types of sensation; it simply activates the level of arousal. Serotonin tells the reticular formation

to ‘quieten’, which prevents an increase in arousal level.

Limbic system – The limbic system contains several structures. Two significant ones for arousal states are the amygdala and hippocampus. The amygdala is your fear center. It is responsible for the fear you feel in your stomach when followed by a stranger in a dark alley. It gets your body ready for ‘fight or flight’. The hippocampus is the memory part of that fear experience. Remember, fear can be real or perceived!

Right orbital frontal cortex – The right orbital frontal cortex is an area of the brain that allows us to feel emotions based on past experiences. It ‘encodes’ the emotional value of people, places, and events. Without proper functioning of this part of the brain, you may laugh at a funeral or make offensive jokes in inappropriate places.

The limbic and right orbital frontal cortex of the brain are instrumental in the memory of the stressful event. The information collected from the heart, stomach, and lungs, during the event, are collected in an area and travel up to the brain via the vagus nerve. Within the brain, the limbic system and orbital frontal cortex encode the feelings associated with the stressful event. In this way, our organs help our brain remember what is important.

Deep pressure by-passes the reticular formation., travels to the cortex and causes the production of serotonin, which tells the reticular formation to ‘quieten’ so there is no increase in arousal. Of course, it is a much more complicated process than simply that, but it illustrates how input from our sensory system produces actual physical changes in the body.

Serotonin interacts with many other neurotransmitters, including dopamine, estrogen, and melatonin. Dopamine has been found in elevated levels in individuals with severe hyperactivity. It is the reward neurotransmitter. Behaviors that feel good typically cause an increase in dopamine. It is the neurotransmitter that is the most addictive. Therefore, the replacement behavior must be more rewarding than the original, less desirable behavior!

The immune, endocrine, and neuro systems are all very interconnected. Imbalance in one often means results for the others. This is important to consider as it is common for individuals with sensory processing disorders to also have problems with digestion and immunity.

Nervous system

The nervous system is divided into two parts, the *somatic* and the *autonomic*. The somatic controls our voluntary organs such as muscles. The autonomic nervous system regulates mostly the involuntary organs and keeps the body in equilibrium. The autonomic nervous system is further divided into two parts, the *sympathetic* and the *parasympathetic*. The parasympathetic regulates conservation and restoration of energy. It causes a reduction in heart rate and blood pressure, and it facilitates digestion and absorption of nutrients. It has a calming effect on the body. The sympathetic enables the body to prepare for fight or flight. It increases heart rate and blood pressure and diverts blood to muscles. It is the ‘adrenaline rush.’ It produces arousal.

If an individual is faced with stress and is in the ‘fight or flight’ state, their system is being bombarded with various chemicals and hormones to increase heart rate, breathing, etc. These substances are only intended for short-term duty in emergency situations. One of those hormones is cortisol, which is very toxic to the brain. For the individual with sensory processing disorders who enter this state on a regular basis due to fluff in socks or tags in clothes, it becomes a significant problem!

Emotions

We are capable of experiencing either positive or negative emotions. There is no such thing as a ‘wrong’ emotion. In fact, negative emotions can push us into action to make changes. However, there can be wrong emotional responses. In other words, if we continue to wallow in negative emotions, we will experience the effects in our body in many ways: damaged immunity, digestion problems, sleep

disturbances, heart disease, anxiety, depression, and the list goes on.

Every thought has a physical effect on our cells. Chemical reactions are produced throughout our bodies by thoughts and emotions. As discussed earlier, emotions are reliant on many neurotransmitters being in a state of equilibrium. Both genetic and environmental influences contribute to this state of balance.

In conclusion

The human body is an incredibly complicated system. We like to separate physical (organs) from neurological (brain), just as we like to separate physical ailments from behavior or mental-health disorders. However, as research is beginning to reveal, they are all completely intertwined with one another. Emotions, behavior, and mental health all have undisputable physical causes and effects on the human body.

With continued research, we hope to better understand how to assist individuals to live a life of optimal equilibrium. It may not be perfect. We may not be able to reverse the genetics of it, but hopefully we can, as Kim remarked, “participate in the individual’s journey of life with a disability.”