

Early Brain Development and Its Implications for Working with Young Children with Sensory Loss

Linda Alsop
SKI-HI Institute
Utah State University

A person's ability to interact, perceive, and learn from the environment comes from the ability to process incoming sensory information and react to the information with a motor response which, in turn, feeds back sensory information.

The Brain

The brain has two basic functions:

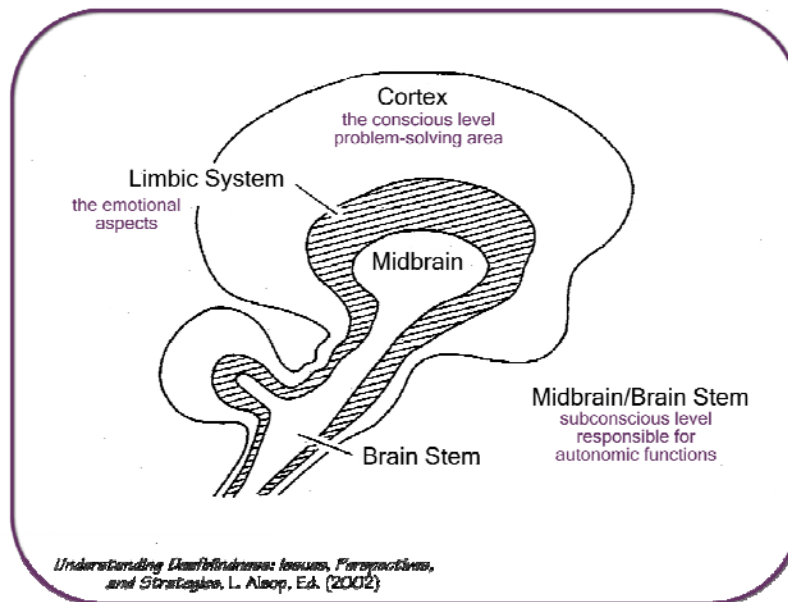
- The first function of the brain is to communicate. The brain communicates by receiving sensory information from the environment via the eyes, ears, nose, mouth, position in space, and nerve endings throughout our body. This information is then sent to other parts of the body via the spinal cord and the peripheral nervous system. Subsequently, the central nervous system (CNS) receives signals from the rest of the body and then plans and sends signals back to the environment. Such response signals may be intentional (e.g., talking, writing, signing) or unintentional (e.g., flushing, startling, breathing heavily).
- The second function of the brain is to integrate incoming sensory information with information already stored in the brain's subconscious and conscious memory banks.

The brain is made up of about two hundred billion interconnected **neurons or nerve cells.**

- A typical nerve cell has a cell body, which is attached to one major fiber or **axon** with a number of fibrous branches called **dendrites**.
- Dendrites receive messages coming into the neurons, which, in turn, combine and integrate the signals.
- The neurons then emit outgoing signals via the axons.
- These neurons communicate with each other via chemical secretions called **neurotransmitters**.
- The more the brain engages in problem-solving activities, the more it develops—not through gaining new neurons but through dendritic branching.
- Most of us are born with more neurons than we need, which is good because some die off even when there is no insult to the brain. Individuals who have suffered from severe neurological insult have had significantly more neurons killed off than would occur under typical conditions. Once a neuron is damaged or dies, it cannot be revived; however, appropriate habilitation or rehabilitation services may assist in promoting the dendrites of remaining neurons to branch out more.
- **Neuroplasticity:** the capacity of the nervous system to modify its organization.

- The first priority of the brain is to keep us alive.
- The second priority of the brain is to enable us to deal with our body and its interaction with the world it senses around us.
- Genetically, we are imprinted to survive.
- Humans are constantly bombarded with stimuli—environmental information about one’s own body, light, noise, temperature, etc.
- The entire CNS needs sensory input, but the input must be meaningful to the brain in order for it to be helpful.
- A confused brain will do what it can to make sense of what it is experiencing.

There are three interacting organizations within the brain – each with its own kind of intelligence, own sense of time and space, memory, motor abilities, and other functions. (See figure below)



Sub-cortical Functions - involve involuntary responses characterized by unintentional and undifferentiated reactions to internal and external experiences often shown through such behaviors as posture, tone, respiration, palloring and so forth

Cortical Functions - are characterized by intentional and differentiated communication, action, and interaction.

Corpus Callosum

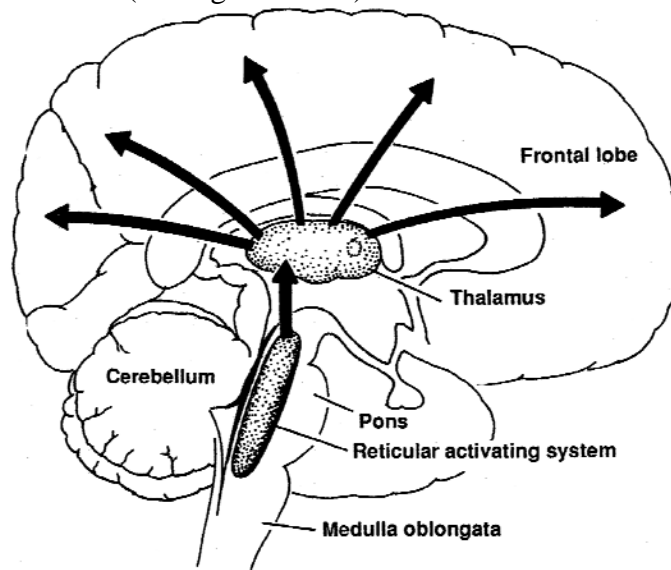
- The brain is divided from front to back into two hemispheres joined together by fibrous tissues called the corpus callosum. It is responsible for passing messages from one side of the brain to the other.

Sensory Systems

- All the information we receive comes through one or more of our sensory systems—eyes, ears, nose, mouth, position in space, and nerve endings throughout the body.

Reticular Activating System

- The incoming sensory information alerts the reticular activating system (RAS) to be prepared to receive and transmit messages. The RAS has to be aroused to perform its functions. (See figure below)

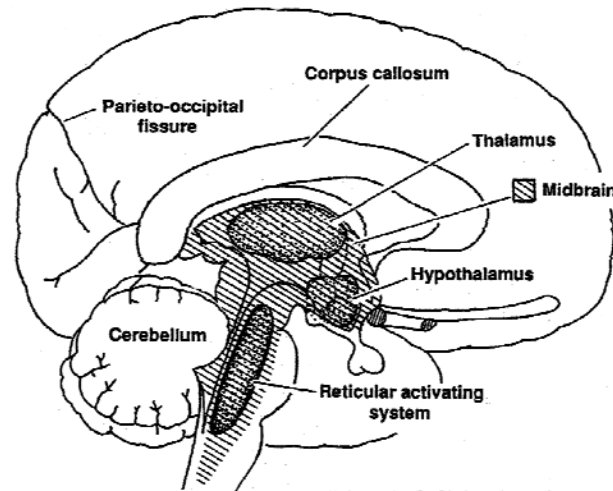


Understanding Disabilities: Issues, Perspectives, and Strategies, L. Altop, Ed. (2002)

- Anesthesia, some drugs, and deep sleep affect the reticular activating system, so there is no conscious processing of the incoming stimuli even though the information has been received and transmitted by the sensory avenue(s).

Thalamus

- The thalamus is a small brain structure that plays a major role in determining which sensory information is going to receive the most conscious awareness.
- All incoming sensory information, except for smell, is “sorted” by importance.
- Information that has been encountered previously, and found to be harmless may be ignored. New information will require more attention until it proves not to be a threat and/or not requiring active attention.
- If the incoming information contradicts existing information, the rest of the brain will be alerted to pay attention to this new information.
- The thalamus helps the rest of the brain to know what is important to attend to and what is not important to attend to. (See figure below)



Understanding Dissociative States, Perspectives, and Strategies, L. Alson, Ed. (2002)

- The thalamus is especially vulnerable to insult that may have occurred in early life, especially if there was a lack of oxygen (anoxia).
- The thalamus, like the RAS, is highly affected by medication.

The Limbic System

- The limbic system evaluates incoming sensory information. It is the brain structures responsible for emotions.
- The limbic system evaluates in two primary ways:
 1. The limbic system finds familiarity comfortable. Novel experiences increase discomfort, which results in stress. The limbic system subconsciously assesses information on a comfort continuum.
 2. The limbic system is the subconscious emotional system that provides subconscious level perceptions. If the limbic system perceives a situation as threatening, a fight or flight response kicks in and the limbic system sends warning signals to the basic power plant (hypothalamus). In turn, the hypothalamus sends out other hormonal signals to prepare for battle.

The brain is programmed to maintain equilibrium.

- When the brain is faced with a new experience, it subconsciously/ subcortically and/or consciously/cortically evaluates the experience. If the experience is understood in the light of previous experiences remembered by the brain, it gets a little excited. Small to moderate amounts of excitement/stress are alerting.
- If however, the experience runs counter to what the brain already knows, then it perceives the situation as potentially threatening, and it prepares to defend itself. Too much stress tips the scale the wrong way and is dangerous for anyone. Stress is the reaction of the body to changes in the status quo.
- When an individual gets angry or frightened, the body mobilizes resources with a primitive response known as “flight or fight.” When this situation occurs, the body automatically releases stress hormones.

Indiscriminate sensory bombardment, as an educational practice, is not justifiable with those individuals who have significant neurological insults.

- If the brain receives too much information and receives it too quickly, it cannot understand, and a state of stress will occur. The results may well be individuals who become more ill than they need to be.
- Every experience needs to be examined from the child's perspective. If stress is at a high level for prolonged periods of time, then the body's physiological defenses may be working overtime.
- If the stress is unrelenting, from the brain's perspective, then the immune system will be affected, and the child may become ill more frequently and/or more seriously.
- Messages received by the olfactory system (smells) are directly processed by the limbic system. Thus, smells evoke memories and strong emotions.

Amygdala and Hippocampus

- The amygdala and hippocampus are part of the limbic system. They are critical in the role of memory, in anticipation, and habituation.
- These two structures and others process events for storage in the subconscious memory bank.
- The hippocampus and amygdala are highly affected by anoxia at birth and are very susceptible to seizures.
- It is critical to use techniques that will assist the child in perceiving the routine of individual activities. It is important to make the situations predictable, interesting, and challenging but not overly stressful.

Hypothalamus

- The hypothalamus is the involuntary center for controlling heart rate, temperature, constriction/dilation of blood vessels, water balance, hormone secretion, appetite, etc.—all functions that maintain physiological equilibrium and life.
- The hypothalamus and limbic system constantly influence each other.
- The observable manifestations of hypothalamic functioning are a critical clue regarding the child's state of arousal, degree of stress, and readiness for learning.
- Many children who have significant neurological challenges may never talk, use sign, write, be effective with technology, or, in extreme situations, use any form of intentional communication.
- These other indices are subcortical, physiological indicators. These unintentional reactions are manifested by such behaviors as posture, tone, respiration, flushing, palloring, and so forth.

Learning

- The systems of the brain regulate a process called "habituation," - a process in which a response to a stimulus becomes automatic.
- The child learns
 - to recognize a stimulus that has been given repeatedly
 - to respond to it in an automatic manner.

- This is the most basic process of learning. It involves sensory receptivity, sensory awareness, attention, discrimination, and memory.
- The ability to learn requires the ability to habituate. Habituation is the process by which the brain gradually adapts to a new event or sensation and no longer consciously notices it, because the event or sensation has been integrated with other information and experiences.
- Orientation: To orient is to be aware that an event is occurring. This is a very early indicator of cognition—the individual recognizes that there is a new stimulus and does something of an autonomic nature to indicate that recognition.
 - To orient to a stimulus involves the ability to neurologically:
 - be prepared to receive, organize, and interpret incoming sensory information at some level;
 - inhibit some information via the thalamus; and
 - re-alert when there is an introduction of a new experience (novelty).
 - Children with severe neurological challenges may orient, but have great difficulty recognizing and remembering a routine. Many of these children will demonstrate the same level of arousal each time the same stimulus is present, and this level of arousal may not lower. These children may not be learning; they may just orient to the stimulus and be aroused. The stimulus, under these situations, does not lose its novelty.

Anticipation

- Anticipation is a higher level of subcortical neurological functioning critical to the learning process. Anticipation is the ability to guess, within a system of predictability, what the next event will be. Anticipation requires attentional processing and the ability to remember an even or a sequence of events.

Routine ⇔ Memory ⇔ Anticipation

Attachment

- Another critical area that frequently is affected by significant neurological insult is attachment. Attachment to a primary or significant person ties in with conditioning and learning.

Working with Children who have Experienced Significant Neurological Insults:

1. The child's reactions and responses may be extremely variable; not just day-to-day but also moment-to-moment.
2. Energy levels may be extremely variable.
3. The child's attention may vary widely depending on:
 - a. difficulties encountered in managing the sensory/motor demands of the task; and
 - b. preference for the activity and/or individual. Sustained attention is a derivative of sustained motivation. Start activities with what the child knows. Gradually introduce novelty in small increments.

4. Motor limitations make it difficult to plan and execute motor responses in a timely manner.
5. Rate and timing of responses by the child may be frequently delayed. Others may step in before the child has had time to process the incoming stimuli, plan and execute a response. The responses of others may be misunderstood by the child.
6. Individuals who have a hard time managing information from the environment may become anxious, stereotypic in their behaviors, and internalized.
7. Health may be affected by stress.
8. Hearing communicative signals of a child who has significant neurological dysfunctioning is difficult. It is important to listen to the physiological and motor cues of the child.
9. Consider the sensory environment. Some environments may be overly aggressive from the child's perspective.
10. Multi-sensory experiences may not be the best teaching route. Introduce one sensory-modality at a time, and build slowly.
11. Consistency and predictability are critical. The introduction of appropriate new (novel) experiences is also critical.
12. Slow down. Pace the interactions.

References:

Understanding Deafblindness: Issues, Perspectives, and Strategies;
L. Alsop (Ed.), SKI-HI Institute, Logan, UT, 2002.

Communicating Research to Practice and Practice to Research: From theoretical contributions to therapeutic interventions. Jude Nicholas, Resource Center for the Deafblind, Norway.

From a presentation given at the 2004 NTAC Topical Workshop
*Taking the First Steps: Critical Practices in Early Intervention and Early
Childhood Special Education for Infants and Young Children with Deaf-Blindness*