

## **Brain-Based Learning Theory**

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### **Abstract**

*The purpose for this quantitative study was to examine whether or not gender-specific strategies improve boys' reading achievement. The review of literature presented in this chapter consists of an overview of existing research related to brain-based learning theory, gender differences, gender-specific teaching strategies, single-sex schools, boys and literacy, and gender-specific literacy instruction. The purpose of this study is to examine whether there is a correlation between gender-specific literacy instruction and the reading achievement of boys in single-sex schools. This review will begin by defining brain-based learning theory and drawing a connection to cognitive gender differences, which will provide a theoretical framework on which to base this study. Next, it will identify and explore brain-based gender differences as well as gender-specific teaching strategies. Furthermore, the literature review defines and discusses single-sex schools and their impact on student achievement.*

In order to consider gender differences in learning, one must understand brain-based learning theory. Brain-based learning is a comprehensive approach to instruction using current research from neuroscience. Brain-based education emphasizes how the brain learns naturally and is based on what is currently known about the actual structure and function of the human brain at varying stages of development (Froschl & Sprung, 2005). In recent years, educators have explored links between classroom teaching and emerging theories about how people learn. Brain research provides us with many possibilities for education, and there is much discussion among educational professionals about how this research should be considered when developing programs and curriculum.

### ***Theories Related to Brain-Based Learning***

For many years, there have been primal models of how our brain works. It was in the mid-1900s that the brain was compared to a switchboard. However, in the 1970s, brain theory began to examine right and left brain comparisons. Later, the brain was referred to in terms of a "triune brain," or a brain in three parts: the lower, middle, and upper sections. The lower brain is responsible for survival learning, while the middle and the upper brain are responsible for higher-level thinking. Presently, brain theory focuses more on a holistic view of the brain. The theory emphasizes a more systems-based approach wherein the whole is greater than the sum of its parts. Within the last two decades, neuroscientists constructed clinical studies using diverse, multicultural groups of people to gather reliable information about how our brains function. This information has been beneficial in determining how human learning actually occurs. Scientists have been looking into how our brain gathers, processes, and retain information (Caine & Caine, 1991). Currently, the research appears to also focus on three key components of human learning and the brain. The following section will review the current research on brain-based learning and examine three major components that influence brain-based learning theory. The research examines the ability of the brain to adapt and grow cognitively, the integration of the brain, and the sophistication or complexity of the brain.

Because of the growing interest in learning and the brain, the attempts to synthesize current research in the area of brain-based learning from a theoretical and practical approach will help to define and describe the characteristics of brain-based learning. Brain-based learning accommodates the learning style of individual students. It is learning with the brain in mind (Jensen, 2005). In his text, *Teaching with the Brain in Mind*, Eric Jensen (2005) explains that “brain learning is a reality check” (p. 77). Thirty years ago, good teaching was defined as lecture, content classes, and quiet students sitting still at their desks. Is this how students learn best? Educators needed to combine the findings of brain research to improve their teaching techniques. “The brain is what we have; the mind is how we use it” (Jensen, 2005, p.77). According to Jensen, it is now known that incorporating intense emotions associated with celebration, competition, or drama can stimulate the release of adrenaline, which strongly enhances memory in learning. Jensen states, “Challenge, feedback, novelty, coherence, and time are crucial ingredients for rewiring the brain” (Jensen, 2005, p.79). In order for connections to strengthen, students need time to think about, digest, and act on their learning. Based on neurological research, Jensen highlights three relevant and essential features of the brain. Adaptability (the constantly changing brain), integration (the structures of the brain that compete and cooperate), and sophistication (the complexity of the brain) will help us to establish the nature of the brain.

### ***Adaptability of the Brain***

The adaptability of the brain reinforces the fact that all children have the opportunity to change and grow cognitively. Environmental events, such as experiences and the actions that you take, lead to changes in your brain (Jensen, 1995). The brain is continually making more connections based on how the individual interacts with the environment (Jensen, 1995). Kemperman, Kuhn, and Gage found that humans can influence the rate of cell growth and also identified factors that enhance or impair neurogenesis. For example, inhibiting factors like excess stress and enhancing factors such as exercise were found to affect neurogenesis (Kemperman, et al., 1998). Based on his research, Jensen contends, “Yes, genetics plays a part in who students are and how they behave and reason, but each of them can change” (p. 13). The adaptability of the brain is relevant to this study in that it has a direct impact on learning. If, in fact, the variables that affect neurogenesis can be manipulated via differentiated instructional strategies, this information would provide support for gender-specific strategies.

### ***Integration of the Brain***

How well the structures of the brain cooperate and compete is defined as the integration of the brain. Cooperation is defined as the way that the different areas of the brain work together to store and prioritize information and complete tasks. Competition occurs when areas of the brain compete for storage space for the behaviors and resources for which they are responsible. Although previous research indicated that the left hemisphere was for logical function and the right hemisphere was for creativity, current research indicates that the left side of the brain processes information in parts, in a sequence, and uses language and text representations (Jensen, 1995). A study done by Richard Davidson at the University of Wisconsin shows that the right hemisphere was activated by negative emotions and the left hemisphere was activated by positive emotions. The left and right hemispheres communicate via the corpus callosum, the large bundle of nerve fibers that connects the two hemispheres. Neurotransmitters carry neural impulses across the corpus callosum, thus allowing the brain to send messages back and forth between the hemispheres. The competition of the brain is representative of a first-come, first-serve mentality. The portions of the brain that are underdeveloped are waiting for signals from the environment to direct them. Whatever comes first, whatever activities are more frequent, and whatever actions are more coherent will influence the network of signals to the brain to allocate space and resources to increase those behaviors (Jensen, 1995). Undoubtedly, the human brain performs many different functions simultaneously. Consequently, learning is enhanced by a rich environment with a variety of stimuli. Therefore, in education, material and content should be presented through a variety of strategies, including physical and artistic student experiences.

### ***Sophistication of the Brain***

The sophistication or complexity of the brain is never more evident than when the process by which learning occurs. Input comes in from outside stimuli and is routed to the thalamus for processing. Meanwhile, the information is routed simultaneously to appropriate cortical structures (occipital and temporal lobes) and the sub-cortical areas (the amygdala).

If it is an emergency stimulus, the amygdale will respond and recruit other necessary brain areas as soon as possible. Later, the information is sent to the hippocampus for more evaluation and is held over time. Over time, the hippocampus will organize, distribute, and connect the memories with other areas of the cortex for long-term memory storage (Jensen, 1995). Although an intensive and complex process, the initial process takes place with lightning speed, but the subsequent process can take hours, days, or even weeks to complete (Jensen, 1995).

Jensen acknowledges seven critical factors in the learning process. Those factors are: engagement, repetition, input quantity, coherence, timing, error correction, and emotional states. Because the developing brain engages in highly complex interaction that needs stimulation, and these interactions that need stimulation prompt the brain to become increasingly specialized, these factors will influence how and what children learn. Engagement, or goal-oriented attention, is the first factor in the learning process. It is important to note that, according to Gazzaniga, 90% of what is learned is the result of unconscious acquisition. With that in mind, engagement is an important part of learning. The simple fact is that if you have your students' attention, they are focused and attend to the lesson or process, and the opportunity for learning increases (Jensen, 1995).

Repetition increases exposure and therefore will strengthen the connections in the brain. Researchers have discovered that repetition strengthens connections in the brain. The synapses are not static. They are constantly adapting in response to activity (Jensen, 1995). Therefore, by following a pattern of presenting information to students, the probability that the students will not only retain the information but also be able to access or activate the information and/or skills learned faster and more accurately in the future is increased (Jensen, 1995). Input refers to how much information is being taken in from outside stimuli and for how long. The human brain needs time for the information to store in long-term memory. This time allows for it to retreat to the long-term memory storage. Providing students too much information without settle time will have a negative impact on learning. In fact, some researchers suggest that it is possible to take in only three to seven chunks of information before overload and new incoming data are missed (Linden et al., 2003). According to Jensen how much time is necessary for the settling to take place depends upon the learner and the material being taught.

According to Jensen coherence is experienced when material is relative as well as relevant. Jensen contends that in order to make connections and develop meaning, prior knowledge of the content must be present and relevant. Providing students with prior knowledge and examples is a critical factor in terms of coherence. Timing is another of Jensen's critical factors for learning. According to Jensen, the brain has many different rhythms or patterns that it follows on a daily basis. One of these cycles, the ultradian rhythm, is approximately 90-110 minutes long. There are about 12-16 of these cycles over a 24-hour period. A cycle consists of high and low periods. Although they can be influenced by outside factors such as exercise, caffeine, or novelty, they are relatively consistent throughout the day. These cycles have an important role in understanding the cognitive performance of the brain.

Jensen defines error learning as learning by trial and error. Although Jensen acknowledges that direct instruction may be the best way to teach certain subjects, he contends that neural networks in the brain become more efficient when a learner tries out several possible options before coming up with the correct answer or solution to a problem or question. The final of the seven factors is emotional stages. According to Jensen, emotions are one of the most important regulators of learning and memory. The intensity of the emotional state influences the likelihood that the event will be remembered. For example, if you experience a high level of fear or ecstasy during an event, you are more likely to remember the event with more detail and develop a deeper connection to it. Researchers have found that negative emotions, such as stress, can reduce cognitive performance because of the suppression of glucocorticoid hormones that influence cognition. Negative events are recalled more easily; they also affect more of our brain circuits. Positive emotions also have an effect on our memory and recall. The neurotransmitter dopamine, which some researchers suggest improves cognitive function, is linked to our perception of positive experiences. Positive experiences, even positive smells, enhance the production of dopamine (Jensen, 1995). Jensen clearly suggests in his text that, although some of the rules for learning that he outlines are naturally built into our systems, our experiences also play a large role in how our brains learn. The links between the emotional brain (amygdale and hippocampus) and the reasoning part of the brain (frontal cortex), for example, have been shown that when impaired as in stress or fear, learning is compromised. In addition, the amygdale is thought to be associated with retention of memories and emotional experiences. This has clear implications for education in the combining of positive emotion to influence learning and memory (Hall, 2005).

### ***Physical Activity and Cognitive Development***

Jensen emphasizes the impact that physical activity has on cognitive development. He suggests that movement will have an impact on the brains of students because it is a natural part of the school day. Kesslak, Patrick, Cotman, and Gomez-Pinilla (1998), in a study on physical activity and brain-derived neurotrophic factor (BDNF), present evidence that confirms Jensen's findings on cognitive processing and moderate exercise. The study points to BDNF as a natural substance that enhances cognition by boosting the neurons' ability to communicate with one another. This supports the statement by Jensen (1995) that "movement can be an effective cognitive strategy to strengthen learning, improve memory and retrieval and enhance learner motivation and morale" (p. 60). Jensen asserts that a critical link between movement and learning can be found in the research on the area of the brain known as the cerebellum.

According to Ivry and Fiez, although the cerebellum takes up one tenth of the brain, it contains nearly half of its neurons and may be the most complex part of the brain. According to Patrick Strick at the Veteran Affairs Medical Center of Syracuse, New York, the part of the brain that processes movement is the same part of the brain that processes learning. His staff traced a pathway from the cerebellum back to parts of the brain involved in memory, attention, and spatial perception. New data from initial studies using functional magnetic resonance imaging (fMRI) have demonstrated support for parallel roles of cognitive structures such as the cerebellum (Jensen, 1995). Oxygen is essential for brain function; Jensen therefore suggests that simple biology would support the connection between movement and learning. Physical activity increases blood flow, which in turn moves more oxygen to the brain. Chemicals such as norepinephrine and dopamine, which energize and elevate mood, are also increased during exercise (Jensen, 1995). Research conducted between 2003 and 2007, including a study done to examine the effects of physical activity on academic achievement, also seemed to support the positive effects of rigorous physical activity in school on cognitive development. Maeda and Randall conducted a study to examine whether taking time for a physical education class in school was detrimental to the academic success of the students. They found that it was not detrimental but in actuality was beneficial to the academic success of the students. Students performed better and were able to accomplish more tasks on the days in which they attended physical education classes. Tremarche, Robinson, and Graham conducted a study to reveal the impact of increased quality physical education time on Massachusetts Comprehensive Assessment System (MCAS) standardized scores. The study implies that students who receive more hours of physical education can score higher on particular subject areas of the MCAS test. Others have used similar comparison analyses of physical education class and achievement. Active Living Research for example, noted the effects of physical education class enrollment and physical activity on academic achievement in middle school students. The data showed that students enrolled in physical education have better academic achievement than those not enrolled in physical education class, due to increased physical activity gained during school time. In addition to the studies focused on physical education within the school day, Stevens, To, Stevenson, and Lochbaum are credited with finding that independent involvement in rigorous physical activity engagement, not the physical education class itself, had a positive impact on academic achievement.

### ***Emotions and Learning***

Jensen also discusses the effects that emotional states have on learning. He emphasizes that, although critics have dismissed the role of emotional states in learning, today's neuroscientists are breaking new ground in helping us to understand why emotions are such an important learning variable. According to Jensen there are seven areas of the brain that are activated by both emotions and learning. They are the thalamus, the hormonal system, the anterior cingulate cortex, the orbit frontal cortex, the nucleus accumbens, the hypothalamus, and the amygdala. Generally speaking, even if the emotion originates in only one part of the brain, it may have an effect on many areas of the brain (Jensen, 1995). Historically, brain researchers have avoided the study of emotions. However, in recent years, noted neuroscientists such as Joseph Le Douarin, Candace Per, Jerome Kagan, Antonio Damasio, and Hanna Damasio have conducted important research that has shaped the way that brain learning is perceived. Research suggests the following about emotions and learning. According to LeDouarin, emotions have their own memory pathways; they create meaning and drive attention. Jensen infers that the research suggests that emotions help to make meaning out of learning and orchestrate our attention and priorities. The brain is typically over-stimulated when strong emotions are present; therefore, emotional events are given preferential processing in the brain (Christianson, 1992). Emotional events also lead to a stronger memory imprint; as a result, our ability to

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recall things in more explicit detail is increased (Cahill, Prins, Weber, & McGaugh, 1994). Recent studies have suggested that threats in the learning environment can have a negative impact on learning, and high levels of stress, over time, can damage cognitive ability (Jensen, 1995).

### ***Social Experiences and Learning***

The final thread for Jensen deals with social experiences and the impact those experiences have on learning. In fact, he is not alone. Gardner identifies social skills as one of the multiple intelligences. Social intelligence is “people smarts,” or the ability to process accurately the intentions of others (Brothers, 2000). The areas of the brain that process social events also process cognitive events as well. Significant social events take place in schools and classrooms; subsequently, students’ brains will be altered by those experiences. Jensen states that it would be irresponsible to ignore the social influence on how students learn.

In addition to the works of Jensen, Renate and Geoffrey Caine have explored the research on brain-based learning. The two have developed a twelve-principle process for teaching with the brain in mind. In the text, *Making Connections: Teaching and the Human Brain*, Caine and Caine present a case for brain-based learning rooted in a synthesis of educational and scientific research. Caine and Cain report that, although the original researchers emphasized the left brain/right brain theory, new scientific evidence points to more communicative hemispheres by which the brain operates. There is significant evidence that the brain operates laterally. That means that there are differences between left and right hemispheres of the brain (Springer & Deutsch, 1993). However, whether a person is dealing with language, mathematics, music, or art, the two hemispheres are inextricably interactive (Hand, 1984; Hart, 1975; Levy, 1985). One side of the brain organizes the information into parts and the other perceives and works with the information in a series of wholes (Caine & Caine, 1991). When either portion is overlooked or neglected, learning becomes difficult.

### ***Processing Information***

A critical component to understanding brain-based learning theory is understanding the complexity of how our brains process information. By doing so, instructional strategies can be developed that support student learning. The human brain is a parallel processor. It is always doing many things at once (Ornstein & Sobel, 1987). Operating simultaneously are our thoughts, emotions, imagination, and pre-dispositions. They interact with other modes of information processing and with the expansion of our cultural knowledge and general social knowledge (Caine & Caine, 1991). Although learning is as natural as breathing, it can be inhibited or facilitated by experiences. According to Diamond, the growth of neurons, nourishment, interaction and emotions are related integrally to the interpretation of experiences (as cited in Caine & Caine, 1991). The research by Caine and Caine supports the theory that stress and threats affect the brain differently than peace, challenge, boredom and happiness (Ornstein & Sobel, 1987). Consequently, everything that affects our physiological functioning affects our capacity to learn (Caine & Cain, 1991). Our learning is greatly influenced and organized by our emotions and mindsets. Both are based on expectancy, personal bias, the need for social interaction, and self-esteem, as well as our prejudices. Our cognition cannot be separated from our emotions (Halgren et al., 1987; McGuinness & Pribram, 1980). Emotions are also important to learning because they facilitate the striate cortex (primary visual cortex) and recall information for memory. The emotional impact of any lesson or life experience may continue to reverberate long after the specific event is over (Rosenfield, 1988).

Although the research on brain-based learning clearly defines how our brains learn, it must be kept in mind that all brains are unique. All humans have the same set of systems, which include the senses and basic emotions, but are integrated in different way in each brain. Learning actually changes the brain; so, individuals become more unique the more they learn (Caine & Caine, 1991). The proceeding review of the literature on brain-based learning, as well as a synopsis of what the research says about how our brains learn, supports the connection between brain-based learning and brain-based gender differences. The following will explore the research on brain-based gender differences.

### ***Brain-Based Gender Differences***

An examination of the structural and functional differences of the male versus the female brain is required to understand brain-based gender differences.

The following section will review literature focusing on brain structure, sensory, physical, and biological differences. The researcher will also examine the literature pertaining to literacy development for both males and females.

### ***Structural and Functional Brain-Based Gender Differences***

Giedd, Castellanos, Rajapakse, Vaituzis, and Rapoport documented the fact that as children mature, the amygdale increases in size more for males, and the hippocampus more for females. The amygdale connects the sensory information, and the hippocampus is involved in making memories. The human brain is divided into two main parts: the left and the right hemisphere. The brain works the same for men and women for the most part, but there are a few major areas of interest as it pertains to sex differences (Giedd, et al., 1997). A later study indicated that the growth of the amygdale was associated with academic strengths in the areas of vocabulary, basic arithmetic, reading single words, and estimated intellectual abilities while the growth of the hippocampus was associated with the academic strengths of spelling, reading, verbal intelligence, and mathematical calculations (Yurgelun-Todd, Killgore, & Cintron, 2003). James states that, “upon entrance to school, the average girl simply is cognitively more ready for school tasks than the average boy of the same chronological age” (p. 26).

Research indicates that gender influences how children learn (Sax, 2006). Those findings do not necessarily mean that boys learn one way and girls learn another. Still, there are significant differences with respect to gender and how our brains develop. Researchers have found that no single area of development influences those gender differences: rather, a combination of developmental differences affects the brain, sensory motor, and physical development. In order to meet the specific learning needs of both boys and girls, educators must first be aware of brain-based gender differences (Sax, 2006).

Research has established that the male brain is on average 10-15 percent larger and heavier than the female brain (Sax, 2005). However, in addition to size differences, autonomy of the brain is present across genders. Using brain mapping, research has established that men possess on average more than six times the amount of gray matter related to general intelligence than women, while women have nearly ten times the amount of white matter related to intelligence than do men. One study done by Kaufmann and Elbel indicates that differences in the brain areas correlate with IQ between the sexes. That study and an ongoing series of other studies make it evident that one part of the male brain, the inferior parietal lobe, is generally larger. That lobe is involved in spatial and mathematical reasoning, or skills that boys tend to perform better than girls. The left side of the brain, which is credited in part for the ability to use language, and connected to verbal and written ability, develops sooner in girls; therefore, girls tend to perform better than boys in those areas (Kaufmann & Elbel, 2001). Although those differences are significant, it is important to examine how that information relates to developmental gender differences. More recent research indicates that the significant difference between girls and boys is not the brain's structure but the size and sequence of development in the different regions of the brain.

In 2007, a longitudinal study conducted by the National Institutes of Health demonstrated consistent sex differences in the speed of the brain's maturation (Lenroot et al., 2007). It also showed that boys' brains develop differently than girls' brains. Rather than develop along the same lines as a girl's brain, only slower, a boy's brain develops in a different order, time, and rate in the areas of the brain that affect spatial memory and motor coordination. While the areas involved in language and fine motor skills mature about six years earlier in girls than in boys, the areas involved in targeting and spatial memory mature some four years earlier in boys than they do in girls (Hanlon, et al., 1999).

<b>Girls</b>	<b>Boys</b>
The female brain experiences 15% more blood flow.	Boys have more cortical area devoted to spatial mechanical functioning and half as much verbal emotive functioning.
Girls are less likely to have attention span problems and are able to transition between lessons quicker.	Boys use more primitive areas of the brain while girls use more the more advanced cerebral cortex area while doing the same tasks.
Girls' brains have stronger neural connectors that create better listening skills, stronger memory storage, and more developed discrimination among the tones of voice.	The male brain goes into rest states in which it renews, recharges, and reorients itself. Girls do this without going to sleep.
A girl's prefrontal cortex is larger and develops earlier than a boy's.	Spatial-mechanical functioning makes boys want to throw things through the air.
A girl's corpus callosum (a bundle of nerves that sends signals across the two parts of the brain) is 25% larger than a boy's. This allows for more talking between the two parts of the brain, which enables girls to multitask better than boys.	Boys' brains are better suited to symbols, abstractions, and pictures. Boys in general learn higher math and physics better than girls. Boys prefer video games for the physical movement and destruction. Boys get into more trouble for not listening, moving around, sleeping in class, and incomplete assignments.
Because girls have more cortical areas devoted to verbal functioning they are better at sensory memory, sitting still, listening, tonality, and the complexities of reading and writing (those skills and behaviors often rewarded in school).	Boys have less serotonin and less oxytocin, which makes them more impulsive and less likely to sit still to talk to someone.
Girls make fewer impulsive decisions than boys due to a higher serotonin level.	Boys structure or compartmentalize learning due to the fact that they have less blood flow to the brain.
Girls are less likely to take risks. They are more likely to underestimate their abilities while boys will overestimate theirs.	The more words a teacher uses during instruction, the less likely they are to listen.

*Note.* Adapted from Sax, L. (2006). Six degrees of separation: What teachers need to know about the emerging science of sex differences. *Educational Horizons*, 84(3), 190-200.

### ***Sensory Perception-Based Differences***

Sex differences are prevalent in sensory perception as well. Studies have found significant differences in boys' and girls' ability to hear, see, and smell (Sax, 2006). Only recently have researchers begun examining sensory perception and sex differences in education. In 2001, Dr. Edwin Lephart, the director of neuroscience at Brigham Young University, became the first to search for sex differences in the way the eye is structured as well as how the visual cortices function in the male versus the female. For instance, the visual cortices of boys are drawn to cooler colors such as silver, black, blue, and gray, and boys tend to draw pictures of moving objects. In contrast, the female eye is drawn to textures and colors. It is also oriented toward warmer colors: reds, yellow, and oranges. Girls tend to draw more detailed visuals with faces and people; boys draw more object-based pictures (Sax, 2006). In addition, in a comprehensive study (Killgore, et al., 2001), newborn infants demonstrated that female infants responded to faces, and male infants responded favorably to moving objects, such as mobiles placed above the cribs.

Although consideration of sensory perception is relatively new, the first evaluation of hearing in girls versus boys was conducted in the 1960s. The study found that girls hear better than boys, especially in higher ranges of frequencies above 2 KHz (Corso, 1963). A later study found that among 350 newborn babies, the girls' hearing was more sensitive than boys', especially in the 1000-1400 Hz range, which is critical for speech discrimination (Cassidy & Ditty, 2001). In addition, more recent studies have confirmed girls' superior hearing at higher frequencies (Corso, 1963). That may be due to girls' shorter, stiffer cochleae, which provide more sensitive response to frequency (Corso, 1963). The research also concludes that such differences increase as children get older. Girls interpret a loud speaking tone as yelling; thinking the speaker is angry, they may tune out. Girls' more finely tuned aural structure makes them more sensitive to sounds than boys (Kaufmann, 2001).

### ***Physical Differences***

Research suggests that boys mature slower physically. They develop gross motor skills before fine motor skills, but they have good targeting skills. The later physical maturation, as well as the lowered hearing response that was discussed in previous literature, may make boys more likely to be identified with attention problems. Unless teachers are aware of these physical differences, the opportunity to provide effective instruction to boys is decreased.

The autonomic nervous system maintains blood pressure, body temperature, and internal homeostasis. It is divided into two parts: 1) the sympathetic nervous system, which is responsible for the “fight or flight” response (the adrenalin-mediated cascade of accelerated heart rate, vasoconstriction, dilated pupils, etc., triggered by violence or confrontation, which prepares the organism to fight or run away), and 2) the parasympathetic nervous system, responsible for “rest and digest,” i.e., mediating digestion and underlying the slower heart rate, vasodilatation, and increased continuous blood flow (flushing) that in turn affect the response to higher ambient temperatures (Sax, 2006).

Studies have demonstrated a gender-related difference in the organization of the two systems. Apparently, the female autonomic system is influenced more by the parasympathetic nervous system; in contrast, the male sympathetic nervous system has a greater influence on the control of autonomic responses. The greatest probable effect of those divisions pertaining to gender is that exposure to threats or confrontations sharpen males’ senses and exhilarate them. Most females exposed to such stimuli feel dizzy and may have trouble expressing themselves or reacting (Sax, 2006).

**Autonomic Differences**

	<b>Girls</b>	<b>Boys</b>
Stress response is influenced more by....	Parasympathetic part of the autonomic nervous system	Sympathetic part of the autonomic nervous system
Primary Neurotransmitter	Acetylcholine	Norepinephrine
Primary Humoral factor	Acetylcholine	Adrenalin
Activation of the system often results in	Freezing or mental slowing, dizziness: feeling paralyzed	Sharpened senses, arousal, excitement: feeling alive
Activation of the system is experienced as	Stressful or unpleasant, possibly nauseating	Thrilling, arousing: desire to do again

*Note.* Adapted from Sax, L. (2006). Six degrees of separation: What teachers need to know about the emerging science of sex differences. *Educational Horizons*, 84(3), 190-200.

**Biological Gender Differences**

In addition to the sensory and physical differences, research supports biological differences among the genders as well. One such difference is the reaction to ambient temperature. Research conducted on ambient temperature in the classroom has reached some surprising conclusions. A study was done by ergonomic specialists with male and female subjects wearing bathing suits, and they found that the ideal ambient temperature is about 71 °F for young men, as opposed to 77 °F for young women. Because the study group wore bathing suits, the ideal temperature in school clothes would most likely be about 2 °F lower or 69 °F for young men and 75 °F for young women (Beshier & Ramsey, 1981).

Dr. Bruce Perry, a Houston neurologist, believes that our current educational system creates an environment that is biologically disrespectful, even if well intended (Gurian & Stevens, 2004). The following table shows some brain-based gender differences in girls and boys. Keep in mind that there can be many variations among the sexes as well; some boys may tend to have the usual girls’ traits and vice versa.

**Brain-Based Genetic Differences in Girls and Boys**

<b>Girls</b>	<b>Boys</b>
Have better hearing than boys and may find “loud” or repetitive noises distracting.	Have more acuity hearing than girls and may lose attention simply because they can’t hear.
Are better at object discrimination, i.e., “What is it?”	Are better at object location, i.e., “Where is it?”
Will focus on faces and things. “Girls draw nouns using warm colors.”	Will focus on movement. “Boys draw verbs using cold colors.”
Use more of the advanced part of their brains, such as the cerebral cortex.	Use more of the primitive parts of their brains, e.g., the hippocampus and amygdale.
Can explain and describe their feelings.	Find it difficult to talk about feelings.
Are more verbal emotive.	Are more spatial mechanical.
Develop language and fine motor skills about 6 years earlier than boys.	Develop targeting and spatial memory about four years earlier than girls.
Multitask well and make easy transitions.	Focus on a task and transition more slowly.
Friendships are focused on other girls.	Friendships are focused on a shared activity.
Conversation is central to a friendship.	Conversation is often unnecessary.
Social hierarchies will destroy a friendship.	Social hierarchies build camaraderie and organize relationships.
Self-revelation and sharing are precious part of a friendship.	Self-revelation is to be avoided if possible.
Often ask a teacher for help and enjoy a close relationship with a teacher.	May not ask for help to avoid being perceived as “sucking up” to a teacher.
Like to be faced, looked in the eye, and smiled at.	Avoid eye contact and prefer you sit beside them.
Retain sensory memory details well and make good distinctions between colors.	Don’t retain sensory details or make color distinctions as well.
Deal with moderate stress, such as timed tests, less successfully.	Deal with moderate stress well and may actually do better because of it.
Want to be with friends when under stress.	Want to be alone when under stress.
Feel “yucky” when faced with threat and confrontation.	Feel excited when faced with threat and confrontation.
Rarely employ aggression playfully.	Often employ aggression playfully.
Connect sex to other outcomes.	Focus on the sexual activity itself.
Use landmarks to give directions.	Use compass points to give directions.
Prefer to read fiction—short stories and novels.	Prefer nonfiction—descriptions of real events, action, and how things work.
Have many friends if they bully and likely bully someone they know.	Have few friends if they bully and more likely don’t know the person they attack.
Need encouragement to build them up.	Need reality checks to make them reassess and to be challenged.

*Note.* Adapted from Gurian, M., & Ballew, A. C. (2003). *The boys and girls learn differently action guide for teachers*. San Francisco, CA: Jossey-Bass.

It can be concluded from the research that there are significant differences in how boys and girls learn. The cognitive differences are brain-based; behavioral difference can be brain-based or a result of responses from brain-based differences. The very architecture of the brain and the resultant differences in sensory perception and physical skills differ markedly between the sexes in the classroom and in society. With that in mind, it is important to examine how these differences influence how boys and girls learn. This study will focus on the specific area of boys and literacy acquisition. The following section will review current literature on the specific area of boys and literacy.

### ***Boys and Literacy***

On the national level, boys are scoring lower in reading than girls. According to Neu and Weinfeld (2007), the gap between the genders in reading increases by 4% from fourth grade to eighth grade and an additional 4% from eighth grade to twelfth grade. Research indicates a trend that is not favorable for boys in the area of reading. In order to understand this trend, the following is a review of the literature on boys and literacy.

### ***Boys' Reading Achievement***

Reading has always been an integral foundation for learning. More recently, an extra emphasis on literacy in the early years puts many boys at a disadvantage (Whitmire, 2010). Literacy demands are being pushed into earlier and earlier grades due to school reform, and boys are, in turn, at a developmental disadvantage when it comes to literacy (Whitmire, 2010). Boys develop language skills later than girls and boys typically need more time. According to Whitmire (2010), the problem is that, without awareness, boys may never catch up.

Peg Tyre, author of *The Trouble with Boys: A Surprising Report Card on Our Sons, Their Problems at School, and What Parents and Educators Must Do*, agrees. She cautions parents to be leery of teachers who do not recognize the learning needs of boys (Tyre, 2008). She points out that boys perform more poorly in reading and writing the longer they stay in school. Boys' failure to keep pace in reading is spawning a "male literacy gap" (Tyre, 2008). In 1999, Dr. Gary Phillips, commissioner of the National Center for Educational Statistics, released the 1998 national report card. Girls did much better in reading and writing. In fact, they did better in all three subjects tested. There has been a failure to connect boys to reading and, as a result, the impact is spreading through our schools. Tyre states that 33% of male high school student's score below basic in national reading achievement scores, and in the middle school, results from the national reading report indicates that the number of boys who are struggling with literacy is astounding. The statistics show that 30% of eighth grade boys score below basic. Even more shocking is that in ten states, 40% of eighth grade boys are barely literate (Tyre, 2008).

Success in reading sets the stage for success at school. Unfortunately, the reverse is true; failure in reading brings failure in school. The research on language development and literacy is definitive on the fact that children who hear and speak many words tend to learn to read sooner and with less difficulty. So what is known about boys and literacy development? There is a general agreement that girls acquire words faster than boys (Maccoby, 1998). Brain research also shows that for both three- and six-month-old girls, the left hemisphere has a higher response to stimuli, whereas for the males, the right hemisphere shows a higher response (Shucard & Shucard, 1990). In addition, one study (De Courten-Myers, 1999) reported that males use their left hemisphere for language while women also use the corresponding areas of their right hemisphere. For both males and females the left hemisphere is slightly larger than the right. However, the difference is that in females, the two sides are more well-balanced (De Courten-Myers, 1999). Due to the fact that females have the advantage in verbal fluency, the laterality of males for the production of language had been stated as the reason that males are not as good at language skills as females (James, 2007). In a literacy study, Smith and Wilhelm (2002) reported that boys generally take longer to learn to read than girls. They read less and are less enthusiastic about it and they have more trouble understanding narrative texts, yet are better at absorbing informational texts (Smith & Wilhelm, 2002). Consequently, the research supports the notion that boys develop language skills later than girls and speak fewer words than girls. That could influence why boys might develop reading skills later than girls, which has an effect on reading ability (Tyre, 2008).

Neurologists have said that boys are born with smaller language centers in their brains and larger spatial centers than girls. Boys develop language abilities at a slower rate, though eventually they catch up. Teachers often say that girls generally learn to read and understand language sooner than boys, which helps to explain why early remedial reading classes are most often heavily populated with boys.

"It goes totally against the brain research showing how young boys and girls develop," says JoAnn Deak, a school psychologist and co-author of *Girls Will Be Girls: Raising Confident and Courageous Daughters* (Deak, 2002). Educational experts contend that most, if not all, teachers are not schooled in dealing with children's brain-based gender differences, and many teachers beyond the third-grade level do not understand that they can do numerous strategies to build up students' reading skills and confidence. Michael Gurian (2003), author and co-founder of the Spokane, Washington-based Gurian Institute, which trains educators in gender differences in learning, believes that if reading and writing instruction is not designed in a boy-friendly way, boys will continue to fall behind.

### ***Gender Specific Literacy Instruction***

Given all of the differences between boys and girls in brain function and learning, it is not surprising to hear many experts call for techniques for teaching reading and literacy that recognize those gender differences. According to Sandra Witleson, a behavioral neuroscience and psychiatry professor at McMaster University in Hamilton, Ontario, there are many anatomical and physiological differences between the male and female brain (Finlay, 2004). A conclusion she draws from those differences is that learning differences probably exist between the sexes and the fundamental physiological differences that exist between boys and girls are differences in inner-ear mechanics, brain structure, and basic neurological wiring (Finlay, 2004)

Gender-specific literacy instruction refers to teaching to the specific learning needs of boys and girls based on what research suggests concerning gender differences. In order to provide gender-specific literacy instruction, teachers need to first be aware of those differences and be willing to modify the instruction to meet the specific learning needs of both boys and girls. The following examines the literature pertaining to gender-specific literacy instruction.

With the preceding literature supporting brain-based learning and gender differences, educators need to consider implementing strategies that will successfully engage both boys and girls in the classroom. One of the first authors to write about the brain in the context of education was Leslie Hart with his text *Human Brain and Human Learning*, first published in 1983. His term "brain-compatible" refers to education that is designed to match "settings and instruction to the nature of the brain, rather than trying to force [the brain] to comply with an arrangement established with virtually no concern for what this organ is or how it works best" (Hart, 1999, p. xi). Hart alleges that those types of environments would surely produce better outcomes.

Gender is an area of brain differentiation that is of high interest. Although for many years it was not acceptable to talk of brain- or biologically-based gender differences, recently researchers have been exploring our brain-based gender differences (Jensen, 2005). One of the foremost gender researchers, Doreen Kimurastates: "Do systematic, meaningful, reliable differences exist in the problem-solving abilities of men and some? The answer is an unequivocal yes" (p. 69). With this in mind, some researchers have identified some gender-specific teaching strategies to enhance learning for both boys and girls. The following is a summary of the latest educational research on gender-specific teaching.

Girls tend to think of their teacher as a friend and ally. They want to please people in authority and get to know them. They enjoy learning in small, informal discussion groups. For these reasons, a "girl-friendly" classroom might have sofas and soft chairs. Since girls enjoy working together rather than individually, teachers would assign two or three girls to collaborate on class presentations and projects. On the other hand, boys tend to learn better in formal situations with clear structure and discipline. Seating should be formal with the teacher clearly in charge of the class. Teachers should use a confrontational style where boys will be directed to answer and explain their reasoning (Sax, 2005). According to Eva Pomerantz, girls value the relationship with their teacher and are at a greater risk of being harmed by a negative assessment from their teacher (Pomerantz, Altermatt, & Saxon, 2002).

Research indicates that girls' hearing is four times more sensitive than boys' (Gurian & Ballew, 2003). This fact has implications for gender-specific teaching. For example, soft-spoken female teachers will put the boys in the back of a classroom to sleep. On the other hand, girls sitting near a teacher with a loud voice will experience him or her as "yelling." Boys will pay more attention in class if the interactions are louder and livelier. Their teachers should not remain seated behind a desk when they lecture but rather keep moving around the room (Gurian & Ballew, 2003).

Girls tend to be critical of themselves and their schoolwork. Although they earn better grades than boys, they are less confident of their abilities. If they do poorly in a subject, they believe they have personally failed their teachers, whom they want to please. For these reasons, girls need praise and reassurance from their teachers. Teachers should reinforce each girl's performance and make her feel competent as a learner (Sax, 2005). On the other hand, boys tend to be very confident, even overly confident, about their academic abilities. If a boy gets a bad grade, he blames it on not working hard enough on a particular day, whereas a girl is more likely to believe she is simply not intelligent enough to master the material. Boys who are only average students with average grades often believe they are brilliant. In general, teachers need to help boys develop realistic attitudes about their abilities and shortcomings (Sax, 2005).

Girls enjoy analyzing the relationships between characters in stories and novels. They like role-playing activities such as performing skits or writing in the voice of another person. A boy's center of emotional thought is in the primitive part of his brain, not in the cerebral cortex as in females. Most boys cannot comfortably answer questions such as "How does this book make you feel?" Boys do not like role-playing activities. In general, they prefer non-fiction that includes descriptions of how things work or of real events such as battles. If they read fiction, they prefer it to be action-oriented (Sax, 2005). In a study conducted in Canadian schools, Gambell and Hunter examined gender differences in genre choice of boys and girls. They found that girls prefer reading popular novels, plays, poetry, and books about contemporary issues, while boys preferred special interest books, sports, news, comic books, and science fiction text. A recent study in the United States found that the genres that the boys preferred were only available in a small portion of the classrooms because the teachers and librarians, most of whom were female, considered the texts that male students preferred were not acceptable forms of literature. Most of the female teachers would select literature for their students based upon their preferences (Gambell & Hunter, 2000).

The perspective from the lens of brain-based learning and gender differences is simple. Proponents of single-sex education assert that merely separating girls and boys into different classrooms will not boost their academic performance. However, Sax believes that if teachers use gender specific strategies and/or methods and if a school sets up its classrooms to accommodate gender differences, academic performance will improve.

### ***Single-Sex Schools***

Single-sex schools based on what the research suggests about gender differences and learning, have brought about a renewed interest in single-sex schools. Although this concept is not new, the rationale for single-sex education is. Prior to the 1960s, single-sex schools were considered appropriate to prepare boys and girls for different roles in life (Cable, 2008). Classes for boys focused on agriculture and industrial arts, while girls' classes focused on home economics. However, in the late 1970s and 1980s, most public schools favored coeducational education over single-sex education based on the feminist movement and the concern that girls were not receiving an equal education. It was not until the past decade that single-sex education has become popular again. With the current research indicating a gender gap based on brain-based gender differences, single-sex education has become an alternative for some parents and their children (Cable, 2008).

According to the National Association for Single Sex Public Education (NASSPE) single-sex education refers to the education of students in an environment that consist of a single gender, either all-male or all-female (NASSPE, 2006). Those environments may be single-sex classrooms in a coeducational school setting or a single-sex school. The perceived gap in achievement between boys and girls has renewed interest in single-sex education. One area of concern in particular is that research indicates that boys are falling farther behind girls. Many parents are growing concerned about the perceived "boy crisis" that has been emphasized by recent reports (Mead, 2006).

Along with growing concern, the publicized success of some single-sex schools has some parents and students who are disillusioned by the current education system considering broader educational choices in addition to home schooling and/or online education (Cable & Spradlin, 2008). One such school in particular was the Young Women's Leadership School in East Harlem. Established in 1996, the school's success impressed Senator Hillary Rodham Clinton so much that she and fellow Senator Kay Bailey Hutchinson proposed an amendment in 2001 to the No Child Left Behind Act that would allow any public school to implement single-sex education programs with little regulation (Sax, 2002).

The amendment was subsequently signed into law in 2001, a law that the National Organization for Women (NOW) opposed strongly, stating that the proposal was “a giant step backward in the struggle for girls’ and woman’s equality” (Sax, 2002, p. 1). A heated debate has begun because of the legality and ethics involving single-sex schooling. Some scientific research claims profound biological differences exist between boys’ and girls’ cognitive, social, and emotional development. However, the critics are concerned and would suggest that we are moving back to a segregated system that once emphasized cognitive differences based on race. They also point out that the segregation would somehow suggest superiority of one gender over the other. Although there is not a lack of debate, there is a lack of valid research that would either validate or refute single-sex education programs (Cable, 2008).

### ***Arguments in Favor of Single-Sex Education***

Proponents of single-sex education argue that it provides opportunities that coeducational classrooms do not. It gives teachers opportunity to engage strategies specifically designed for boys or girls in each content area, designed with gender-specific learning needs in mind. Dr. Leonard Sax, founder and executive director of NASSPE, claims that scientists have found profound differences between boys and girls (Sax, 2005). The manner in which our brains develop and are wired, along with the hearing and response to stress difference, are among the major factors that he emphasizes in support of single-sex schools (Cable, 2008). Advocates of single-sex schools contend that in a single-sex environment, teaching can be tailored to fit the different needs of male or female students and therefore help both sexes attain higher levels of academic achievement (Cable, 2008). Supporters of single-sex education cite studies that indicate that students in single-sex schools are performing at higher levels of achievement.

One such study was conducted at Woodward Avenue Elementary School in Florida by researchers at Stetson University. The study compared the test scores of two fourth grade classes in the school, one single-sex and one co-ed. The demographics, number of students, and teacher training were equivalent in both classes. After three years, the researchers reported that the boys in the coeducational classes scored 37% proficient, while the boys in the single-sex classrooms scored at 87% proficient. In addition, the girls in the coeducational class scored 59% proficient, as opposed to the girls in the single-sex classroom who scored 75% proficient (Piechura-Couture, Tichenor, & Heins, 2007). A similar study was conducted at the Thurgood Marshall Elementary School in Seattle. The school was a failing school in the poorest neighborhood of the city. The principal restructured the school into a dual academy with separate-sex classrooms. The scores changed dramatically. On the Washington Assessment of Student Learning (WASL), the boys’ scores increased for math from the 10<sup>th</sup> percentile to the 66<sup>th</sup>. Prior to the change, not one girl had passed the math portion of the WASL. However, after the restructuring, 53% of the girls passed (Sax, 2005). Sax also argues that a lack of professional development in gender-specific teaching is to blame in converted single-sex schools that are unsuccessful.

### ***Arguments opposing single-sex schools***

Those who oppose single-sex education suggest that single-sex education fosters gender stereotyping. Some argue that focusing on gender detracts from other subgroups that need the most help (Mead, 2006). According to Sarah Mead, the senior policy analyst at Education Sector, boys are achieving more than ever (Mead, 2006). A report by the American Association for University Women (AAUW) published in 2008 found that both boys and girls are more likely to graduate than in 1976 (Mead, 2006). It also reported that both sexes’ standardized test scores have risen or remained stable (AAUW, 1998). Mead also suggests that focusing on the gender issue is taking away from the subgroups that she claims need the most help. She identifies those groups as African American, Hispanic, and low income students (Mead, 2006). Her argument is that schools should be changed to meet all students’ needs.

David Sadker, an American University professor who has published many gender and education articles, also has concerns about single-sex education. He believes that the superiority of single-sex schools, when it is apparent, occurs not because of the separation of genders but because of the pedagogical factors one would find in any effective school (Bracey, 2006). The executive director of The Great Lakes Center for Education Research and Practice believes that focusing on what is known to work, such as hiring quality teachers, providing professional development, smaller class sizes, and providing effective early childhood education, is the answer (Battaglieri, 2006).

Critics of single-sex education also contend that the positive results are not based on the single-gender aspect but point to factors such as smaller class sizes, hiring better teachers, and the socioeconomic status of the students and the teachers (Cable, 2008). Jannette Elwood, co-director of *Failing Boys: Issues in Gender and Achievement*, in a review of recent research on the achievement of girls in single-sex schools, argues that the focus should be improving the education for both sexes (Why girls' schools do well, 1999). Elwood reports that her study in the UK on girls in single-sex classes found that the girls did score better on achievement tests. However, she suggests that the reason was that they were high-achieving students regardless of their environment (Why girls' schools do well, 1999). Advocates of coeducation believe that many of the proponents of single-sex schools base their support on gender stereotypes or mistaken notions of the sex/gender distinction. They argue that single-sex classrooms are structured to perpetuate gender stereotypes. In addition, they argue that single-sex schooling is not representative of real life or workplace experiences (Cable, 2008). The U.S. Department of Education's summary of their single-sex versus coeducation schooling systematic review had mixed results according to critics. Bracey claims that most of the studies on single-sex and coeducational schools showed little difference in achievement.

Clearly, the debate has just begun concerning single-sex education. While single-sex education has been identified by some researchers as being instrumental in increasing student achievement for all students (Sax, 2006), it is still facing opposition from skeptics who doubt that single-sex education will have any positive benefits. Some who oppose single-sex education claim that this is just another bandwagon idea that will fail to produce statistical evidence of its benefits and will lead educators and administrators back to stereotypical patterns that faced boys and girls in the 1960s (Mead, 2006).

### **Conclusion**

It is evident that there is a gap in the literature regarding the impact of single-sex education and the reading achievement of boys. Although the proponents of single-sex schools cite many studies of successful single-sex schools, those studies are of small sample size. The vast majority of literature focusing on single-sex education has been conducted in private and/or parochial settings. The studies that were conducted in public schools have been limited to one school or even one classroom.

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