Balancing Act: The Vestibular System in the Classroom

Kay de Veer, MEd, ET

Abstract

The vestibular system is the foundational neurological system in our body, and it supports balance, coordination, and spatial orientation. It is also responsible for integrating one's auditory, tactile, visual, and proprioceptive systems. These systems affect students' ability to maintain attention and perform academic tasks, such as reading and writing. Heightened awareness of the vestibular system in early elementary classrooms is necessary to identify and support students with vestibular dysfunction. Pregnancy, home life, community, and preschool experience are all factors that can impact the development of the vestibular system in primary years. The vestibular system can be compromised in a child of any environment or socio-economic class. A research study was conducted to determine if a specific protocol could enhance early elementary educators' understanding of the vestibular system. The research findings showed that a 20-minute training on the vestibular system enhanced educators' language, understanding, and awareness of the vestibular system and its important role in the early elementary classroom.

Introduction

The ability to be successful, both academically and emotionally, is closely tied to a child's sense of physical balance (Blythe, 2004). The vestibular system is the neurological sensory system that is responsible for balance integration (Dunn, 1999; Kranowitz, 2005). Today, many children are losing opportunities to develop their vestibular systems from birth to age five. This is due, in part, to a loss of interaction with the real-world because of an increased usage of personal devices among children (both at home and in school) as well as an academic-heavy pre-school and kindergarten experience (Radesky & Christakis, 2016; Robb, 2017; Shepard & Smith, 1988). These factors are limiting opportunities for students' sensory systems to develop, leading to an increase in vestibular difficulties in the early elementary classroom. To investigate this topic further, an original research study was conducted to determine whether a specific protocol could enhance early elementary educators' understanding of the vestibular system. A vestibular system screener was designed specifically for this study and reviewed by six occupational therapists, after which twelve early elementary educators were trained in its use. The educators' pre-training and post-training knowledge was collected through an online survey to examine the effectiveness of the training. Results showed that a twenty-minute training enhanced educators' knowledge of vestibular system function in the classroom and prepared them to use the screener. One conclusion reached through the research was that further awareness of the vestibular system is necessary. Early elementary educators are eager to learn more about this vital function and how they can help students for whom vestibular issues have been identified.

What is the Function of the Vestibular System?

There are seven sensory systems in the human body: auditory, tactile, proprioceptive, visual, gustatory, olfactory, and vestibular (Mehta & Stakiw, 2004). (See Figure 1.) Sensory processing is when the nervous system receives messages from the senses and turns them into appropriate responses (Mehta & Stakiw, 2004). The vestibular system, also known as the foundational sensory system (Aryes, 1978; Dunn, 1999), is responsible for organizing the tactile, vestibular, proprioceptive, and visual sensory systems. It integrates these systems by sending and receiving inputs from the systems to the cerebellum to produce motor output and balance (Bush & Dougherty, 2015; Nandi & Luxon, 2008; Ottenbacher, 1980). As seen in Figure 2, the central vestibular nuclear complex processes sensory inputs from the peripheral vestibular apparatus (also known as the inner ear) while simultaneously processing extra-vestibular sensory information from the proprioceptive, auditory, and visual sensory systems (Bush & Dougherty, 2015; Nandi & Luxon, 2008; Ottenbacher, 1980).

If the vestibular reflexes are performing effectively, eye movement, stability and balance, and spatial orientation are smooth and efficient. If they are not performing efficiently, it is difficult for individuals to focus their eyes, balance their heads, or maintain their awareness when moving in space (Bush & Dougherty, 2015; Nandi & Luxon, 2008).

Research by Carmona, Holland, and Harrison (2009) states that the vestibular system is neurologically connected to emotional regulation. The right hemisphere in the brain is specialized for vestibular awareness and is also the dominant hemisphere responsible for expression of emotion (Carmona et al., 2009). Carmona et al. (2009) also cite the prefrontal regions' involvement in many related regulatory roles: paying attention, effectively modulating motor function, determining appropriate sensory input, filtering during stressful vestibular challenges, and assessing of dizziness and disorientation. Daly and O'Connor (2009) add, "The cerebellum is strongly influenced by the vestibular system and is the part of the brain involved in regulating our movements so that they can become automatic, precise and well-controlled" (p.22). Therefore, the vestibular system, balance, and emotional regulation are neurologically connected.

The vestibular system first begins to develop in a mother's womb when a fetus explores the sensation of up and down (Carmona et al., 2009; Nandi & Luxon, 2008). Nandi and Luxon (2008) explain, "At birth the [vestibular] system is morphologically complete but developmental maturation continues and is most prominent in preschool years, helping the child develop balance, control, and movement" (p.1). Both human motor development and a child's ability to stabilize vision during head movements are related to vestibular processing function (Nandi & Luxon, 2008). Vestibular function responsiveness reaches "adult values" by 10-14 years of age (Nandi & Luxon, 2008). When typical developing milestones are delayed, further evaluation and assessment of the vestibular system should be done immediately (Bythe, 2005; Nandi & Luxon, 2008).

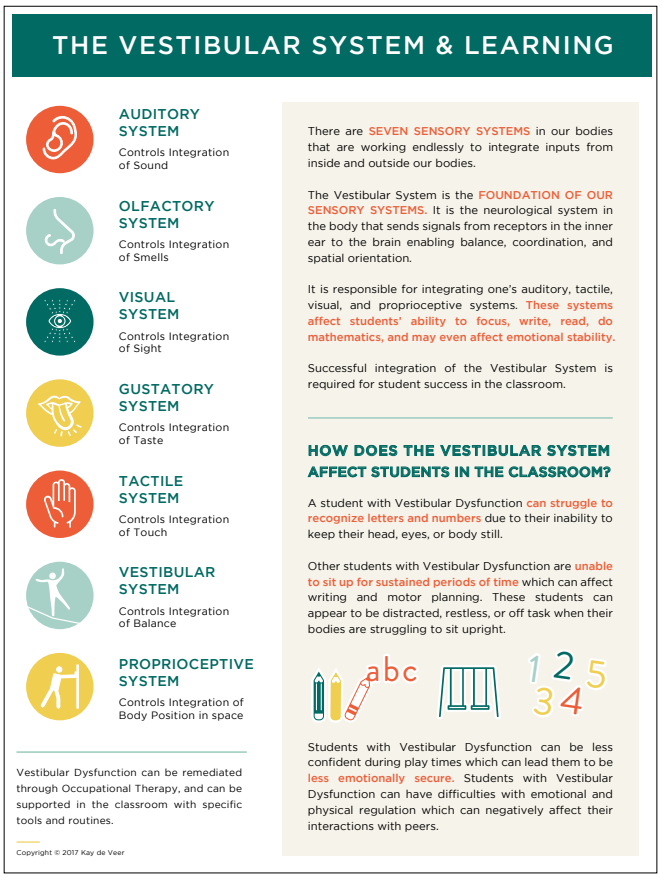

FIG. 1 – Click image for full-size PDF.

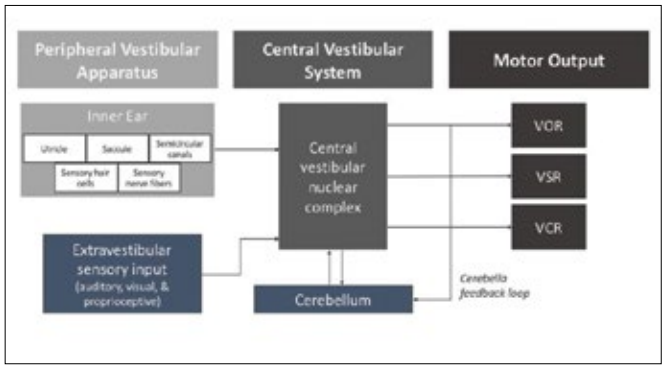

FIG. 2

(Mehta & Stakiw, 2004)

VOR (vestibulo-ocular reflex) controls the muscles of the eyeball to create eye movement.

VSR (vestibulospinal reflex) stabilizes the body during positional changes and motion by controlling limb movements required for necessary positioning of a head on the body.

VCR (vestibulocollic reflex) serves to stabilize the muscles in the head.

How does Vestibular Dysfunction Manifest in the Classroom?

The vestibular system is important for all students in the classroom, not just students with learning disabilities. Vestibular organization is directly related to proper visual, auditory, and proprioceptive accuracy. Therefore, it can greatly affect a child's ability to focus, read, write, and do mathematics (Ayres, 1978; Kranowitz, 2005). It is important to note that vestibular processing is a developmental part of every human's neurological system and can be compromised in a child of any socio-economic class, environment, or geography (Chan, 1995). Although vestibular disorders are not life threatening, they can greatly affect a child's quality of life in school (Mehta & Stakiw, 2004).

Students with disorganized vestibular systems can struggle to recognize letters and words due to the inability to keep their necks, heads, or eyes still when reading (Chan, 1995). This can cause words on a page to move, jump, or shake, leading to various academic difficulties (Aryes, 1978; Kranowitz, 2005). Other students may be unable to sit up for long periods of time due to a lack of balance, another symptom of vestibular dysfunction (Dunn, 1999). According to Carmona et al. (2009), the vestibular system's function supports regulation and arousal in children throughout their day. Therefore, students with vestibular dysfunction can appear unfocused, hyperactive, or unmotivated.

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Sensory processing disorders, including vestibular dysfunction, disrupt the processing and integration of complex information which can affect the intellectual, social, and emotional development of children in school (Owen et al., 2013). While many students may present with normal variations in development, the developmental dysfunction of an individual's vestibular system falls on a spectrum between over and under responsive (Ayres, 1978; Dunn, 1999; Parham, Ecker, Kuhaneck, Henry, & Glennon, 2007). Ahn, Miller, Milberger, & McIntosh (2004) explain that any sensory processing dysfunction can negatively affect behavioral, emotional, and cognitive success in the classroom. A student who has an under-responsive vestibular system might be looking for input from spinning, rocking, lying down, or inverting his head on a desk or the floor. A student who has an over-responsive vestibular system might be hesitant in various activities, including going up and down stairs, going down slides, or spinning (Blythe, 2004).

Children with vestibular dysfunction are often clumsier and less coordinated than their peers. This discourages movement and play on the playground, which can affect social relationships and sometimes emotional development (Blythe, 2004). A child who is less coordinated might be less social or less willing to participate in physical activities, leading to lower self-confidence. A child with vestibular dysfunction might become upset more easily due to a constant feeling of physical imbalance (Blythe, 2004; Daly & O'Connor, 2009). It is vital for children to explore the world around them through climbing, running, jumping, and movement to continue to develop their vestibular system and their understanding of balance. Through exploration, children learn that gravity will pull their bodies down when they fall (Aryes, 1978; Blythe, 2004; Daly & O'Connor, 2009; Kranowitz, 2005). Children with vestibular dysfunction are less likely to feel confident in this understanding of gravity due to their lack of confidence with balance. This can cause chaos in a child's mind and exacerbate other social difficulties that come up in the school day (Aryes, 1978; Ketcham & Burgoyne, 2015). Problems related to vestibular dysfunction become more apparent once a child enters a school-like environment that by its nature causes them to interact with more sensory stimuli in the classroom and on the playground (Ahn et al., 2004). Ahn et al. (2004) continue, "The fear, anxiety, or discomfort that accompanies everyday situations may significantly disrupt daily routines in the home environment. Moreover, school environments contain physical and social stimuli that frequently cause these children significant distress" (p. 288).

Children with vestibular dysfunction are often not able to advocate for themselves as they are not aware that what they are experiencing is abnormal and hence cannot communicate their needs (Mehta & Stakiw, 2004). Children who are affected by vestibular dysfunction can appear fatigued, angry, unfocused, or clumsy when they enter the elementary classroom (Chan, 1995). Vestibular dysfunction can negatively impact a child's ability to make friends, build confidence, and navigate social situations. These students are more likely to be misinterpreted as students with behavioral issues, hyperactivity, or an inability to focus in a classroom environment (Mehta & Stakiw, 2004). According to Mehta and Stakiw (2004), there is a high occurrence of psychological disorders, most commonly anxiety disorders, associated with patients with vestibular problems. These behaviors can also be caused by factors beyond the vestibular system, but adults in the child's life should be aware that a vestibular dysfunction is an issue that should be taken seriously. It is instrumental to recognize a child's over- or under-responsive vestibular system in their formative years in order to begin meaningful and effective therapy (Mehta & Stakiw, 2004). Such therapy may prevent painful learning and/or social experiences that often result from vestibular problems.

Why Should Vestibular Function be Assessed?

Due to the many factors that go into a child's development, including home life, community, and preschool experience, there is no clear baseline to determine "school readiness" (Christoffersen, 2009; Hatcher, Nuner, & Paulsel, 2012). While

social and emotional aspects of development are becoming more valued within child development standards, research around kindergarten readiness fails to acknowledge sensory integration or, more specifically, vestibular function. More students would be set up for success upon entering kindergarten, both emotionally and academically, if the importance of the vestibular system's role in childhood development was more widely understood by caregivers, parents, educators, and educational specialists. Sally Blythe (2005) wrote:

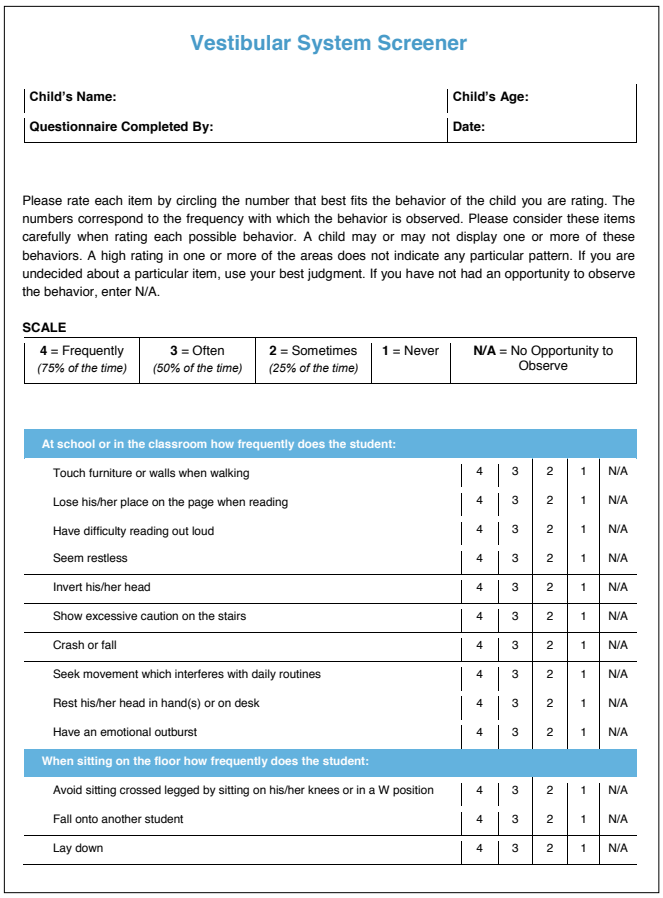
> More extensive use of tests for neurological dysfunction within the school system could help to identify those children who are underachieving as a direct result of underlying neurological dysfunction so that their developmental problems can be corrected enabling them to perform to a higher level. (p. 429)

Outside of the educational realm, the assessment of the vestibular system can be done across various settings including but not limited to occupational therapists, physical therapists, otolaryngologists, audiologists, optometrists, and developmental optometrists. However, a dearth of awareness and knowledge exists within the pediatric medical profession about the role of the vestibular system in child development. Consequently, there is an inability to effectively support this vital system during the formative years (Ahn, et al., 2004; Mehta & Stakiw, 2004; Nandi & Luxon, 2008).

Vestibular processing disorders, along with other sensory processing disorders, can be isolated disorders but may also coexist in children with attention deficit hyperactivity disorder (ADHD), behavioral disorders, or autism. As such, they can be difficult to assess and identify (Ahn et al., 2004; Owen et al., 2013). Due to high rates of co-morbidity with other processing disorders, differential diagnosis is vital when assessing the vestibular system. Particularly, vestibular processing disorders and attention processing disorders can be challenging to differentiate because these disorders share several clinical characteristics. The behavioral responses of children with vestibular over-responsivity can manifest as distractibility, impulsivity, and hyperactivity, mirroring ADHD (Miller, Nielson, & Schoen, 2012).

The Referral Process

Though developmental variations in vestibular function may not be uncommon, it can be helpful to use a screener to record observations when it is suspected a child might have a vestibular processing dysfunction. The screener created for the present research (Figure 3) is intended to be a lightweight, non-normed assessment in which educators could record observations of their students' vestibular function. This screener is not meant to either define or diagnose a need but rather to begin a conversation with parents about observations an educator might be seeing. Although no formal training is required to use this screener, the research showed that a 20-minute training on the vestibular system screener increased the educators' ability to use scientific language and to have a better understanding of sensory integration when describing what they are observing in the



Vestibular System Screener

Child's Name:	**Child's Age:**
Questionnaire Completed By:	**Date:**

Please rate each item by circling the number that best fits the behavior of the child you are rating. The numbers correspond to the frequency with which the behavior is observed. Please consider these items carefully when rating each possible behavior. A child may or may not display one or more of these behaviors. A high rating in one or more of the areas does not indicate any particular pattern. If you are undecided about a particular item, use your best judgment. If you have not had an opportunity to observe the behavior, enter N/A.

SCALE

4 = Frequently *(75% of the time)*	**3** = Often *(50% of the time)*	**2** = Sometimes *(25% of the time)*	**1** = Never	**N/A** = No Opportunity to Observe

At school or in the classroom how frequently does the student:					
Touch furniture or walls when walking	4	3	2	1	N/A
Lose his/her place on the page when reading	4	3	2	1	N/A
Have difficulty reading out loud	4	3	2	1	N/A
Seem restless	4	3	2	1	N/A
Invert his/her head	4	3	2	1	N/A
Show excessive caution on the stairs	4	3	2	1	N/A
Crash or fall	4	3	2	1	N/A
Seek movement which interferes with daily routines	4	3	2	1	N/A
Rest his/her head in hand(s) or on desk	4	3	2	1	N/A
Have an emotional outburst	4	3	2	1	N/A
When sitting on the floor how frequently does the student:					
Avoid sitting crossed legged by sitting on his/her knees or in a W position	4	3	2	1	N/A
Fall onto another student	4	3	2	1	N/A
Lay down	4	3	2	1	N/A

FIG. 3 – Click image for full-size PDF.

classroom (de Veer, 2017). This language is vital when sharing observations that indicate possible vestibular dysfunction or sensory needs. Once observations are shared with the family, recommendations may be made, if appropriate, for the child to see a pediatric occupational therapist who has a specialty with sensory processing. All children are developing their vestibular systems, and since these difficulties fall on a spectrum, some behaviors observed on the screener may just indicate normal variations in development. It is important to share with families that the screener is a tool used to organize observations in the classroom but not a tool to diagnose or define a child profile.

Occupational therapists interviewed for the research generally agreed that a screener built specifically for educators in the classroom would be helpful in the referral process. This would give occupational therapists an opportunity to gain knowledge about the child's classroom experiences. One occupational therapist, S.P., shared:

> This screener would give me a slice of information from a teacher's perspective that I don't usually get right away. I will still do all of my assessments with a child, but this gives me a picture of what they look like in the classroom. It would help support the background information of the child in the school setting before moving onto a normed test. (S.P., OT, personal communication, January 4th, 2017)

How is Vestibular Function Assessed?

When a child is referred to an occupational therapist (OT), an initial consult is performed to determine if or what therapy is required (S.P., OT, personal communication, January 4th, 2017). This process includes gathering information about the child from parents and educators as well as specific assessments of the child by the OT. Within the occupational therapist community, one or more of the following standardized assessments are used to measure a child's sensory processing abilities: The Sensory Profile (Dunn, 1999), The Sensory Processing Measure (SPM) (Parham, Ecker, Kuhaneck, Henry, & Glennon, 2007), and the Sensory Integration and Praxis Tests (SIPT) (Ayres, 1989). The SPM has an assessment component that is meant for educators to fill out according to their observations in the classroom and is used in conjunction with other aspects of the assessment. If therapy is recommended, the parent and education team can work together to design the best plan to support the child in various settings (S.P., OT, personal communication, January 4th, 2017).

What Strategies Will Support Vestibular Function in a Classroom or Small Group Setting?

Many strategies can be put in place in a whole group, small group, or one-on-one setting to support students who have vestibular dysfunction. These supports are beneficial to all early elementary students, as all students of this age group are developing their vestibular systems (Chan, 1995). Research and professional experience have shown the following approaches to support vestibular function.

"Vestibular dysfunction can negatively impact a child's ability to make friends, build confidence, and navigate social situations."

Creating a "safe space" where a child can go when experiencing sensory overload is important in any environment (Chan, 1995). A safe space should include an area where a child can give a signal to move himself to a quiet, low-input part of the room. Tools, such as noise canceling headphones or visual blockers, can be effective in helping support sensory regulation in this safe space or even while a child is working (Chan, 1995).

All students, especially those with vestibular dysfunction, need opportunities to move throughout the day. Intentional "body breaks" and extended time on the playground are all vital when used strategically (Chan, 1995). Sensory tools can be effective when specific management strategies are put in place. An observational study done by Ketcham and Burgoyne (2015) found that sitting on therapy balls in the classroom provided proprioceptive and vestibular support. Students who were sitting on therapy balls were able to rock and bounce rather than sit stationary in a chair, thus engaging the vestibular system. This activity supported healthy sensory integration and helped with balance by providing the brain with information about the position of the head in space to help with balance (Ketcham & Burgoyne, 2015). It is vital, though, to set clear behavioral expectations around students' use of therapy balls, "wiggle seats," or any sensory-related tool. However, when specific management strategies are in place, sensory tools can be effective. Regardless of the chair being used, it is instrumental for students' feet to be able to touch the ground (J.S., OT, personal communication, January 6th, 2017). When students' feet are not touching the floor, they cannot ground their bodies or balance themselves effectively in a chair. Proper grounding of their feet supports postural control, motor planning, fine motor control, and writing success (J.S., OT, personal communication, January 6th, 2017).

The S'cool Moves program, researched and designed by Debra Wilson, integrates specific physical movement into a classroom's routines, thereby supporting sensory integration. When S'cool Moves' effectiveness was researched, the following was concluded: "Findings suggest short-term, sensory-based interventions implemented in natural classroom environments among at-risk students can enhance their engagement in school occupational performance" (Wilson, 2015, p. 6). S'cool Moves is intended to support the sensory systems, including the vestibular system and visual processing systems, through specific activities that engage vision tracking, balance, and postural control (Wilson, 2015). S'cool Moves encourages wall push-ups as an effective and simple body break for before, during, or after any lesson. Students can be asked to read sight words or do simple mental math problems while holding the paper vertically on the wall performing wall push-ups simultaneously. Wall push-ups are a low risk way for students to gain vestibular and proprioceptive input. The purpose is not for students to build arm strength, but rather for students to experience the pressure-related feeling from moving their body weight towards and away from the wall.

Calming routines or meditative strategies can support students who are feeling dysregulated. Start lessons with deep breaths, and give students an opportunity to share how their bodies and minds are feeling that day. When students are aware of their breath and their bodies, they are more aware of their regulation. Calming routines can also include self-soothing inputs. For example, have students use one hand to squeeze up and down their other arm gently. Also, have them use their hands to give themselves a mini ear massage, knee massage, or elbow massage (Wilson, 2015).

Activities that engage the core are generally beneficial for students with vestibular needs (J.S., OT, personal communication, January 6th, 2017). Such activities can be used as simple body breaks throughout the session. For example, set a timer to do a body break every 10-15 minutes for 30 seconds at time. Include wall push-ups, planks, sit ups, or jumping jacks. Allow students the opportunity to stand while they are working by having standing-height tables in the office or classroom (S.P., OT, personal communication, January 4th, 2017).

When implementing strategies, it best to confer with an occupational therapist to ensure they are being used in proper form and input. Students can either have an under- or overly-stimulated vestibular system. If children have an under-stimulated vestibular system, they will be seeking input such as spinning, jumping, rocking, or bouncing. Jumping jacks might be a successful body break for these students. Student who are overstimulated will come across as more cautious, timid and will avoid further vestibular input. Calming routines will be most beneficial for these students.

Conclusion

The vestibular system is responsible for integrating one's auditory, tactile, visual, and proprioceptive systems. Although vestibular dysfunction can affect a child's academic and emotional development, there is a dearth of understanding of its importance. Students continue to develop their vestibular system in early elementary grades; therefore, all children will benefit from educators' better understanding of vestibular functioning. Through brief trainings for educators, parents, and caregivers on how the vestibular system supports learning in the classroom, students with vestibular dysfunction can be more easily identified and supported in their crucial development years.

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Kay de Veer, MEd, ET, *holds a bachelor's degree and multiple-subject teaching credential from Cal Poly, San Luis Obispo, as well as an MEd and Educational Therapy Certificate from Holy Names University of Oakland, California. Kay worked as an educational therapist in San Francisco before founding Key Learning, a private educational therapy practice in Santa Barbara, California. Readers interested in more information, or who would like a full-sized copy of the screener or vestibular informational document, may visit her website at www.keylearningsb.com.*