

## Dyslexia

Haslum & Miles (2007) took a look at how many children with dyslexia also have problems with motor skills, such as poor balance. To do so, they tested 12,950 children with dyslexia using five tests of motor performance: (a) balancing on one leg, (b) throwing a ball in the air, clapping and catching it, (c) walking backwards, (d) sorting matches and (e) graphaesthesia (recognizing shapes drawn on the palm of the hand). Of all the children tested, 35.3% failed one motor test and 16.4% failed more than one. This means that 51.7% of children with dyslexia also had difficulty with motor skills (coordination, balance). Therapists often remark that many children with developmental disorders affecting cognition (thinking skills, reading, learning) also demonstrate difficulty with handwriting, coordination, and balance. Here is some validation for their observations!! At the very foundation of thinking and motor skills is timing in the brain, more specifically synchronized timing of neural transmissions between centers of the brain that are part of a neural network governing thinking and moving. In order to effectively address dyslexia at its root, professionals must address mental timing skills as part of their therapy regimen. Interactive Metronome (IM) is a patented training program for improving mental timing, or synchronization between centers of the brain responsible for cognitive and motor skills.

*Haslum, M.N. & Miles, T.R. (2007) Motor performance and dyslexia in a national cohort of 10-year-old children. Dyslexia, 13, 257-275.*

It is widely known that children with developmental dyslexia do not perceive auditory timing and rhythm cues in speech as well as typically developing children (i.e., when emphasis is placed on syllables or pauses are inserted to change the meaning of the message). In this interesting study by Thomson et al (2006), the authors investigated whether this problem with timing and rhythm was specific to speech or whether this problem with perceiving timing and rhythm was more generalized, affecting learning and literacy skills. Another question they asked was whether these timing problems seen in children would also be found in adults who've received therapy or remediation services for dyslexia. They found that there is a strong relationship ("coupling") between auditory and motor skills, a finding that other researchers have also pointed out. They also found evidence that the relationship between auditory and motor skills is linked to literacy (the ability to learn to read and write), even into adulthood. Longer-term ("longitudinal") research studies are now examining this issue beginning in infancy or early childhood to better understand this relationship and its effect on literacy. This may ultimately lead to earlier diagnosis and treatment for children with dyslexia. This is one of many current research studies that have identified a core deficit in mental timing (or timing in the brain) in individuals diagnosed with dyslexia. The Interactive Metronome (IM) is a flexible treatment program that addresses the underlying problem with timing and rhythm with engaging exercises and measurable results. IM can be easily administered and integrated with traditional remediation programs for dyslexia.

*Thomson, J.M., Fryer, B., Maltby, J., and Goswami, U. (2006). Auditory and motor*

*rhythm awareness in adults with dyslexia. Journal of Research in Reading, 29(3), 334-348.*

This study by Boets et al (2007) shows that the cause of dyslexia, like autism, cannot be determined that readily... there is just no simple answer to a complex problem. Their research shows that some individuals with dyslexia have difficulty with basic processing of time-sensitive information in the speech stream ("auditory temporal processing") leading to a problem with phonological processing. While Boets and his colleagues did show that pre-literacy skills (or the ability to go on and learn to read and write) likely results from an underlying problem with phonological processing in some individuals, they also identified that this cannot be the sole cause in all cases of dyslexia and may just be a piece of the overall puzzle. They also found that some of the children with this same phonological processing disorder did not go on to develop literacy problems or dyslexia. Other children with relatively good phonological processing skills went on to develop dyslexia. In some of these children, a specific visual dysfunction was diagnosed (visual magnocellular processing). The bottom line appears to be that more research is needed and that it should focus on multi-factorial causes of dyslexia, rather than trying to find a single cause. This also illustrates that no single treatment for dyslexia is likely to be beneficial for all of those who are diagnosed with it!! Interactive Metronome (IM) may be an important part of the overall treatment for individuals with dyslexia who demonstrate difficulty with phonological processing by addressing "auditory temporal processing," or the speed with which the brain can register, interpret, store, and retrieve information originating through the auditory channel. Phonological skills and reading have repeatedly been shown to improve following IM training.

*Boets, B., Wouters, J, van Wieringen, A, and Ghesquiere, P. (2007). Auditory processing, speech perception and phonological ability in pre-school children at high-risk for dyslexia: A longitudinal study of the auditory temporal processing theory. Neuropsychologia, 45, 1608-1620.*

In this study, Edwards et al (2004) looked for differences in "temporal processing" (or timing in the brain) between children who were progressing normally in reading and children with dyslexia. They found that 76% of the children with dyslexia had difficulty processing temporal information (a problem with mental timing or timing in the brain). They also noted that the problem with mental timing affected either auditory or visual processing, but not both in the same. The Interactive Metronome is currently the only program available for assessing and improving timing in the brain, thereby enhancing auditory and/or visual processing necessary for reading and writing.

*Edwards, V.T., Giaschi, D.E., Dougherty, R.F., Edgell, D., Bjornson, B.H., Lyons, C., and Douglas, R.M. (2004). Psychological indexes of temporal processing abnormalities in children with developmental dyslexia. Developmental*

According to Farmer & Klein (1995) and other researchers such as Tallal (1984), a problem with hearing how one sound differs from another is at the heart of many cases of dyslexia. Some go further to suggest that this problem is just a symptom of an underlying “auditory temporal processing deficit.” What is this exactly?? Here is an example: As a teacher is talking to her students, their brains must process all of the rapidly changing acoustic variables of speech (voice onset time, voice offset time, pauses, pitch, frequency, amplitude, etc). If there is any background noise (in the hallway, someone whispering, paper crumpling, erasers erasing, ...), then their brains must ALSO filter out this information to focus on accurately processing what is said. Each of our brains process time-related information...understanding speech is just one example of how our brain must do this. If the child’s brain cannot keep up with the pace of information and process it timely, then an auditory temporal processing deficit results. This then makes it hard to decipher what the sounds are or what is being said, and in turn leads to problems with reading and writing. The Interactive Metronome is a flexible training program and is the only treatment that effectively addresses the underlying problem with timing in the brain. Research shows that following IM training, reading comprehension & fluency improve significantly. IM training is available in both clinic and virtual (home) settings.

*Farmer, M.E. & Klein, R.M. (1995). The evidence for a temporal processing deficit linked to dyslexia: A review. Psychonomic Bulletin & Review, 2(4), 460-493.*

Hari & Renvall (2001) have proposed that individuals with dyslexia demonstrate “sluggish attentional shifting.” They claim that this in turn affects the brain’s ability to process “rapid stimulus sequences,” like that contained within speech. They go on to explain that once a person with dyslexia engages his attention, it is hard for him to disengage from what he is focused on and shift his attention to something else. Ultimately, this causes a delay in processing. If a person cannot shift attention in a timely fashion, then information will be missed. They discuss experimental data that backs up their theory. There are current studies that provide yet more information about the role of temporal processing (or timing in the brain, in particular millisecond timing) in attention, specifically for executive-controlled attention or the ability to self-direct attention. The time-dependent skill of attention (better yet, executive-controlled attention) can be improved significantly with Interactive Metronome training, a program that promotes synchronicity and timing in the brain through progressive exercises that are motivating and engaging and real-time millisecond feedback for timing.

*Hari, R. & Renvall, H. (2001). Impaired processing of rapid stimulus sequences in dyslexia. Trends in Cognitive Sciences, 5(12), 525-532.*

In this paper entitled, *Dyslexia and A Temporal Processing Deficit: A Reply to the Commentaries*, Klein and Farmer defend their 1995 paper which proposed that a problem with hearing how one sound differs from another is at the heart of many cases of dyslexia (in essence, a problem with timing in the brain). If you keep up with dyslexia research, you know that there are many confounding theories out there and no one seems to have THE definitive answer for what causes dyslexia. The authors stated “the three commentaries [following their 1995 publication] raise some interesting and provocative points about the temporal processing deficit hypothesis. However, after careful consideration of these points, we are not dissuaded from our original conclusion that the evidence available from a variety of paradigms is compelling enough to warrant further investigation into the temporal processing deficit and its possible causal role in a number of cases of dyslexia. In addition, the questions of causality (auditory temporal processing deficit → phonemic deficit → dyslexia, and visual temporal processing deficit → dyslexia) need thorough investigation, as does (do) the possible developmental course(s) of a temporal processing deficit in the auditory and visual modalities.” There is more and more evidence today that domain general functions like attention, working memory, and processing speed are dependent upon temporal processing, or timing in the brain, for efficient flow of information, processing, storage, and retrieval...all of which impacts development and learning. Interactive Metronome is an engaging and motivating program that trains the brain to keep time more precisely, thus improving many of the symptoms seen in ADHD, Autism, Dyslexia, and other developmental and acquired disorders.

*Klein, R.M. & Farmer, M.E. (1995). Dyslexia and a temporal processing deficit: A reply to the commentaries. Psychonomic Bulletin & Review, 2(4), 515-526.*

Here is yet another study exploring whether a deficit in mental timing or timing in the brain may underly the problems seen in dyslexia (Laasonen et al., 1995). These authors show that a temporal processing deficit has a broad impact on individuals with dyslexia, impacting audiotactile, visuotactile, and audiovisual modalities. They also found that the ability to process time-related information in speech (“temporal acuity”) was positively related to phonological awareness in dyslexic readers. As we have seen from other studies, problems with phonological awareness is not only a common symptom of dyslexia, but a precursor in many cases. Research shows that following specific training to improve “temporal processing” or timing in the brain with Interactive Metronome 4 out of 5 critical pre-reading skills improve, including phonological awareness.

*Laasonen, M., Service, E., and Virsu, V. (2002). Crossmodal temporal order and processing acuity in developmentally dyslexic young adults. Brain and Language, 80, 340-354.*

Kevin McGrew, PhD, Director of the Institute of Applied Psychometrics and critical member of the Interactive Metronome Scientific Advisory Board, has compiled a bibliography of references for research on dyslexia. Please use this link to access the list.

*Kevin McGrew. (2007). "Temporal processing" and "dyslexia" keyword matches in IAP (www.iapsychy.com) Reference Database*

Due to the complex nature of dyslexia and its likely multifactorial causes, Martin (1995) advocates for a case study approach to research rather than looking at a group of individuals with dyslexia together. He argues there are so many differences between individuals with dyslexia that it may be more valuable to study them one at a time, reporting data from each case separately. What do you think?

*Martin, R.C. (1995). Heterogeneity of deficits in developmental dyslexia and implications for methodology. Psychonomic Bulletin & Review, 2(4), 494-500.*

Interesting. You would expect that if timing in the brain or the ability of the brain to process the components of speech timely were the problem behind dyslexia, then talking slower or presenting information more slowly should help them better understand. Right? If processing is delayed, then slow down the information and voila (!) ... better comprehension. This is exactly what Rey et al (2002) found, lending credence to one of the predominant theories about the cause of dyslexia...that timing in the brain or what is known as "temporal processing" is impaired. Research shows that the auditory system is malleable, or trainable, with the right kind of regimen. Interactive Metronome is a patented program that measures timing in the brain and gives a score (in milliseconds), reflecting the efficiency with which your brain is processing or keeping time. IM is also a training program that improves timing and rhythm through progressive exercises and real-time feedback for millisecond timing. Research shows that millisecond timing is critical for auditory processing, speech, and language.

*Rey, V., De Martino, S., Espesser, R., and Habib, M. (2002). Temporal processing and phonological impairment in dyslexia: Effect of phoneme lengthening on order judgment of two consonants. Brain and Language, 80, 576-591.*

Professionals who incorporate timing and rhythm into the treatment of dyslexia and other speech/language and learning disorders via synchronized metronome tapping, Interactive Metronome, music, singing, drumming, or other method report it to be beneficial. Here is a really interesting article about how the brains of individuals with dyslexia are organized differently when compared to children who are good readers and spellers. They also explained how this contributes to a breakdown in mental timing or what is known in the research world as "temporal processing" based upon what they've learned from fMRI studies. What is so encouraging

is that after they provided a specific treatment where the children were taught the code for connecting letters and sounds with an emphasis on timing, they rescanned the brains and found the brain had made more normal connections. "Following the treatment, the fMRI scans showed that the patterns of temporal connectivity in brains of the dyslexic children had normalized and were similar to those of the good readers and spellers." Interactive Metronome (IM) provides not only a stimulus for timing but also feedback so that the individual can specifically improve mental timing (or "temporal processing") at the millisecond level critical to speech, language, and cognitive abilities. IM is a flexible tool that can be combined with any treatment program to enhance overall outcomes.

*Richards and Berninger. (2007). Having right timing 'connections' in brain is key to overcoming dyslexia. National Institute of Child Health and Human Development. Back to Eurek Alert.*

The ability to perceive speech early in life appears to have a great impact on later ability to read and spell. As we've seen in other studies, the brain is flexible and can be molded if given the right intervention to correct a defect or strengthen an area of ability. In the case of dyslexia, researchers have shown that "temporal processing" (or timing in the brain) is significantly impaired and this affects speech discrimination and listening comprehension, which in turn affects reading, spelling, language development, and learning. They showed that when the timing (or "temporo-spectral characteristics") of speech was manipulated in a daily, intensive treatment regimen of auditory exercises, individuals with dyslexia improved significantly in their ability to understand speech. Other researchers then took this a step further and studied the brains of persons with dyslexia under fMRI before and after this intervention and found that indeed their brains showed functional reorganization as a result of neuroplasticity! Our brains are flexible and can overcome problems like dyslexia with the right treatment. The authors of this study (Santos et al., 2007) demonstrated that a problem with pitch-perception may also contribute to deficient phonological representations in dyslexics that may, in turn, lead to impaired development of reading skills.

*Santos, A., Joly-Pottuz, B., Moreno, S., Habib, M., and Besson, M. (2007). Behavioural and event-related potentials evidence for pitch discrimination deficits in dyslexic children: Improvement after intensive phonic intervention. Neuropsychologia, 45, 1080-1090.*

Many studies now show that there is a link between auditory temporal processing and dyslexia. In this study, Schulte-Körne et al (2006) show that phonological awareness is central to speech discrimination. Speech discrimination in turn is critical for good spelling ability. Previous researchers have identified this same relationship between phonological awareness and reading ability. Remember, phonological awareness is the ability to hear the difference between speech sounds, or the sound structure

of one's language. This is a critical building block for reading and writing. Researchers and professionals in clinical practice have shown that following training with the Interactive Metronome to improve auditory temporal processing, students show significant progress in the areas of phonological awareness and reading as measured with standardized tests such as Comprehensive Test of Phonological Processing, Test of Word Reading Efficiency, and the Woodcock Johnson III Tests of Achievement.

*Schulte-Körne, G. Deimel, W., Bartling, J., and Remschmidt, H. (1999). The role of phonological awareness, speech perception, and auditory temporal processing for dyslexia. European Journal of Child & Adolescent Psychiatry, 8(3), 28-34.*

Neural imaging (with fMRI) allows researchers to look inside the head of individuals with dyslexia to see how the structure and function of their brain differs from that of people who possess normal development of reading and writing skills. Some studies have shown problems in the posterior left side of the brainstem while other studies revealed problems with function in the front part of the brain. These studies were conducted on adults and the results were then generalized to children, making inferences about how differences in brain function influence the development of dyslexia. In this paper, Shaywitz et al (2002) decided to actually study the brains of a large sample of children with dyslexia using fMRI to determine whether these brain abnormalities seen in the adults were likely present in early childhood at the time they were learning to read and write or whether the brain abnormalities resulted from a lifetime of poor literacy skills. They found that, indeed, the children with dyslexia exhibited decreased activation of the left posterior hemisphere of the brain during reading as compared to normal readers.

*Shaywitz, B.A., Shaywitz, S.E., Pugh, K.R., Mencl, W.E., Fulbright, R.K., Skudlarski, P., Constable, R.T., Marchione, K.E., Fletcher, J.M., Lyon, G.R., and Gore, J.C. (2002). Disruption of posterior brain systems for reading in children with developmental dyslexia. Society of Biological Psychiatry, 52, 101-110.*

Virsu et al. (2002) investigated whether problems with mental timing ("crossmodal temporal processing impairment") present in young dyslexic individuals worsens as they age. They measured "cognitive temporal acuity" ... in other words, mental timing, ...at millisecond levels. They found that the temporal processing impairment worsened with age. They explained the worsening over time with the following statement: "...developmentally dyslexic readers appear to have, on average, a weaker than normal neuronal system responsible for processing rapidly changing temporal sequences." With all of the research supporting a deficit in temporal processing in the majority of cases of dyslexia, it would appear that it would be essential to emphasize timing and rhythm in the treatment of the disorder. Interactive Metronome is an engaging technology that measures & improves timing and rhythm with an emphasis on all of the areas important in dyslexia: audiotactile, visuotactile and audiovisual.

*Virsu, V., Lahti-Nuuttila, P., and Laasonen, M. (2003). Crossmodal temporal*

*processing acuity impairment aggravates with age in developmental dyslexia. Neuroscience Letters, 336, 151-154.*

As some researchers have pointed out, not all individuals with dyslexia have a problem with phonological awareness (knowledge about the sound structure of one's language), and some individuals who do have a problem with phonological awareness do not go on to develop dyslexia. While there is a definite relationship between phonological awareness (a critical pre-reading skill) and later development of dyslexia, this does not explain all cases of dyslexia according to Valdios et al (2004). They propose that some cases of dyslexia may be linked to a core problem with visual attention. Others have pointed to potential "magnocellular temporal processing deficits" that may result in basic visual and auditory processing impairments, linking the auditory and visual problems that some think are actually separate problems. This is all so confusing for a parent of a child with dyslexia who is looking for the right treatment! It is obviously critical for professionals to carefully evaluate each individual so that the appropriate intervention can be applied to achieve the best possible outcomes, i.e., to determine where the child's strengths and weaknesses are rather than relying on any one theory about what may be causing dyslexia. Interactive Metronome is a flexible treatment tool that can be used in the evaluation process to help determine where processing is breaking down, whether in the auditory or visual channel, and to address auditory (phonological awareness) or visual (attention, processing) skills while emphasizing the "temporal processing," or mental timing component that underlies both.

*Valdios, S., Bosseane, M.L., and Tainturier, M.J. (2004). The cognitive deficits responsible for developmental dyslexia: Review of evidence for a selective visual attentional disorder. Dyslexia, 10, 339-363.*

Researchers have identified that in some cases of dyslexia, there is a core deficit in the "magnocellular channel" of the visual system, which is responsible for rapid temporal visual processing. They have also determined that in other cases, it is the auditory system that is the problem, or inability to process rapid auditory sequences (an auditory temporal processing deficit). While some have argued that these problems are separate and not seen in the same individual, McAnally et al. (2003) suspect they are and that they are part of a more global sensory processing problem. They call for future research to more carefully evaluate whether these deficits co-exist. At the heart of both problems is a central deficit in timing, or "temporal processing." Professionals who incorporate Interactive Metronome, a patented program that measures and improves timing in the brain, into the treatment of dyslexia and other learning disorders, report that the majority of individuals initially demonstrate poor timing and rhythm and that as timing and rhythm improves, so does attention and reading/academic achievement. This has also been demonstrated in clinical research.

*McAnally, K.I., Castles, A., and Stuart, G.W. (2003). Visual and auditory*

*processing impairments in subtypes of developmental dyslexia: A discussion.*  
*Journal of Developmental and Physical Disabilities, 12(2), 145-156.*