

## **Auditory Processing Disorder and Reading Difficulties**

### **What is auditory processing?**

Auditory processing can be described simply as “what the brain does with what the ear hears” (Florida Department of Education, 2001, pg. 2). As sound travels through the ear it causes structures inside the ear to vibrate. These vibrations are then changed into electrical energy. The electrical energy travels through nerves in the central auditory nervous system to the brain. In the central auditory nervous system sound is interpreted, recognised and processed; this is called Central Auditory Processing (La Trobe University, 2010).

Efficient auditory processing results in a number of auditory abilities that are vital in the listening and communication process, these include:

**Auditory discrimination:** the ability to discriminate between words and sounds by their duration (long vs. short), intensity (loud vs. soft) or frequency (high vs. low). Auditory discrimination can affect reading, spelling, writing and following directions. This skill is particularly tested in noisy environments where it becomes increasingly difficult to discriminate between sounds and words that are acoustically similar eg. *thin and fin*.

**Sound localization:** is the ability to identify where the acoustic signal is coming from relative to the listener’s position. Localization contributes to one’s listening efficiency.

*Auditory attention:* the ability to direct one's attention to the relevant sounds, specifically speech, and hold that attention for an age-appropriate period of time.

*Auditory figure-ground:* the ability to identify the primary auditory signal from background and/or competing noise.

*Auditory closure:* the ability to comprehend the entire word or message when part of it is missing. This skill is used to understand messages in noisy listening environments.

*Auditory synthesis:* the ability to blend or merge single phonemes into words. This is critical for reading success.

*Auditory analysis:* the ability to recognize phonemes or morphemes that are embedded in words. This skill is needed to distinguish verb tense (e.g. jumped vs. jumps) and other markers that may be masked or lost by background noise.

*Auditory association:* is the ability to identify the sound and attach meaning to it through labeling. It also involves the association of the sound with the language or non-language acoustic signal. Auditory association facilitates the development of auditory memory.

*Auditory memory:* is the recall of the acoustic signal after it has been labeled, and stored. (Florida Department of Education, 2001)

### **What is auditory processing disorder (APD)?**

Auditory processing disorder (APD) is a sensory processing deficit found to occur in approximately 5% of school-aged children (Kids Health, 2010). It is the inability or reduced ability to discriminate, recognize or understand auditory information. APD adversely affects listening, comprehension, language and learning (Florida Department of Education, 2001). To learn one needs to listen to, attend to, and identify the important auditory signals over all other competing noises at school and at home. Evidence suggests that underlying deficits in auditory processing may cause children with APD to experience hearing difficulties in spite of normal hearing sensitivity. Children with APD are often distracted by, or may not hear clearly when background

noise is present; they may find it difficult to follow spoken instructions and often misinterpret what is said; they may have trouble understanding degraded speech and or identifying and discriminating between speech sounds (Sharma, Purdy & Kelly, 2009; Harper & Weiner, 2010; Florida Department of Education, 2001). These difficulties make learning more difficult and as a result children with APD often find school challenging (Florida Department of Education, 2001; Kraus & Banai, 2007).

The American Speech-Language-Hearing Association (ASHA) describes APD as occurring when difficulties in one or more of the following areas are observed: auditory discrimination; sound localization; auditory pattern recognition; decreased auditory performance in the presence of background noise, competing acoustic signals and/or degraded acoustic signals (ASHA, 1996). When difficulties occur in these areas the fidelity of the acoustic signal is compromised. If sounds cannot be accurately identified and discriminated between they will be misrepresented in the auditory cortex and thus not processed accurately by the brain (Sharma, Purdy, Newall, et al., 2006; Ahissar, Protopapas, Reid & Merzenich, 2000).

It has been suggested that auditory processing deficits adversely affect one's ability to detect and process speech patterns, resulting in impaired or "fuzzy" phonological representations, specifically required for speech perception. Unclear phonological representations are likely to lead to impaired phonological awareness which in turn may result in the development of reading problems/disorders (Sharma et al., 2006; Ouimet & Balaban, 2009; Rosen, 1999).

### **Phonological awareness- An essential skill for reading**

Before a beginning reader can learn how to decode letters into sounds they must first understand that words are made up of sounds and that speech sounds (phonemes) can be represented in written spellings (the alphabetic principle) (Lyon, 2000). They must also have phonological awareness; the knowledge that spoken language can be broken down in various ways:

sentences into words, words into syllables (e.g. bro/ther) and syllables into phonemes (e.g. /c/ /a/ /t/).

Phonemic awareness is a component of phonological awareness involving the ability to hear, isolate and manipulate phonemes, for example the early reader must be able to hear the “at” sound in ‘sat’ and ‘bat’, and recognise that the difference between the words lies in the first sound. A child with phonemic awareness should also be able to manipulate this sound to form similar sounding or rhyming words e.g. cat, fat, mat (Hoover, 2002; Lyon, 2000; Westwood, 2008).

Strong phonological and phonemic awareness and a good understanding of the alphabetic principle are fundamental skills for reading development and success (Wendling & Mather, 2009). If a child cannot hear the phonemes in words they are unlikely to be able to manipulate them. Consequently they may struggle with learning how to relate the sounds they hear to the letters in written words (the alphabetic principle) and as a result will struggle to decode words efficiently and accurately (Westwood, 2001).

A deficit in phonological awareness is believed to be the primary reason why many children have difficulty learning to read (Sharma et al., 2006; Blau et al., 2009; Ouimet & Balaban, 2009; Rosen, 1999; Ahissar, et al., 2000)..

### **Dyslexia- A deficit in phonological awareness**

Dyslexia, otherwise known as specific reading disorder, is the most frequently diagnosed learning disability with reported prevalence rates ranging from 4-10% (Blau, Reithler, van Atteveldt, et al., 2009; Ouimet & Balaban, 2009; Rosen, 1999). Dyslexia is characterized by persistent difficulties in spelling and reading despite adequate instruction, motivation and intelligence (Sharma et al., 2009; Blau et al., 2009; Rosen, 1999). To be a successful reader one must have adequate knowledge of, and fast access to, the speech sounds (phonemes) corresponding with the letter combinations (graphemes) being read (Sharma et al., 2006; Ouimet & Balaban, 2009).

If these sounds are not accurately retrieved, represented or stored reading problems can arise (Ouimet & Balaban, 2009). A popular and current explanation for dyslexia is that there is an underlying deficit, in phonological processing/awareness, characterized by difficulties discriminating, recognizing and sequencing speech sounds (Sharma et al., 2006; Blau et al., 2009; Ouimet & Balaban, 2009; Rosen, 1999; Ahissar, et al., 2000). Along with poor phonological awareness, children with reading disorder (RD) consistently exhibit impaired phonemic awareness (Sharma et al., 2009; Sharma et al., 2006; Ahissar, et al., 2000).

### **Auditory Processing Disorder- A cause of Reading Disorder**

APD results in the inability or reduced ability to discriminate, recognize or understand auditory information. It is characterized by inefficient auditory processing abilities which can cause deficits in phonological awareness (ASHA, 1996; Sharma et al., 2006; Ouimet & Balaban, 2009; Rosen, 1999; Westwood, 2001).

A deficit in phonological awareness is believed to be the primary reason why many children experience reading difficulty/disorder (Sharma et al., 2009; Sharma et al., 2006; Ahissar, et al., 2000). Because APD results in poor speech perception and impaired phonological representations, it could be hypothesized as follows:

- If APD is the primary impediment underlying a child's reading disorder, it is the major factor responsible for the child having difficulties with learning to read (Sharma et al., 2006).

### **Research**

Several researchers have identified a relationship between auditory processing disorders (APDs) and reading disorders (RDs) (Sharma et al., 2006; Rosen, 1999; Ahissar, et al., 2000) with some claiming a causal relationship between the two. Many studies report that children with RDs perform poorly on auditory processing tasks and that the coexistence of APD

and RD is common (Sharma et al., 2009; Sharma et al., 2006). Correlations have also been found to indicate a link between auditory processing, phonological awareness and reading disorders (Sharma et al., 2006).

Sharma et al. (2009) investigated the percentage of children with APD who had a coexisting reading or language disorder. Sixty-eight children aged 7-12 years participated in the study all of whom had either a diagnosis of APD or were suspected to have APD. Participants completed tests of auditory processing, language, reading, attention and memory. Results found that 72% of participants had an APD. Of these, 67% had APD coexisting with reading disorder (RD), language disorder (LD) or both (47% had APD, RD and LD; 10% had APD and RD; 10% had APD and LD). Only 4% of participants were identified as having an APD in isolation. These results reveal that a pure diagnosis of APD is uncommon and that APD is most likely to occur in combination with reading and language disorders (Sharma et al., 2009).

Another study linking APD and RD aimed to systematically investigate the differences between individuals with current RD, past RD and no RD, on auditory processing tasks. The assessments used to measure auditory processing and reading ability included: the Castles word/nonword reading test, Wheldall assessment of reading passages, Peabody picture vocabulary test, Dichotic digits test, Frequency pattern test, Random gap detection test and Speech-in-noise test. All participants in the study were aged between 8-12 years. Sharma et al. (2006) compared the results of 23 children with RD (reading scores 2 or more years below same age-peers) to a “compensated” group of 15 individuals whose parents reported a previous history of reading difficulties which required intervention, but whom reportedly had age-appropriate reading skills at the time of the study. Both RD and compensated groups were also compared to a control group of 21 children with no previous reading or learning difficulties. Results showed that children in the RD group had significantly lower performance on tests of auditory processing than the compensated reader group and control group. Test results also found that all children in the RD group had considerable deficits on at least one test of

auditory processing, indicating auditory processing problems. Additionally, children in the RD group were found to score poorly on tests of non-word reading. This is consistent with having a phonological awareness problem. These results support the previous studies findings that APD and RD often co-exist and indicate a relationship between auditory processing, phonological awareness and reading (Sharma et al., 2006).

A study by Blau et al. (2009) used functional magnetic resonance imaging (fMRI) to investigate the brain areas involved in the processing and integration of letter-speech sounds. Eighteen children with a diagnosis of dyslexia were compared to 16 children with no history of reading impairment. Both groups had a mean age of 9 years. All participants were tested on various measures of reading using a standardised computerised reading test. The test battery also included a phoneme-deletion task to assess phonological abilities, a decoding task to assess spelling ability and a letter-sound matching task. The fMRI was used to identify the parts of the brain activated in successful readers, compared to those with dyslexia. Results demonstrated that children with dyslexia differ from fluent readers in the way they process letters, speech sounds and letter-sound combinations. Dyslexics were found to have reduced neural integration of letter-speech sounds in the auditory cortex, as well as reduced brain activity when processing speech sounds. The auditory cortex is part of the central auditory nervous system. It is this system that is responsible for auditory processing; recognizing, interpreting and processing sound. Reduced neural integration and brain activity in the auditory cortex is likely to negatively affect sound identification, discrimination and representation. These findings confirm that letter-speech sound integration, in the auditory cortex, is important in learning to read and that it develops differently in those with reading disorders (Blau et al., 2009).

Another study using a control-group conducted by Ahissar et al. (2000) aimed to clarify the relationship between auditory processing and reading ability. One-hundred-and-two adults aged 16-58 years participated in the study. Participants either had a childhood history of reading difficulties (CHRD) or no

history of reading difficulties (control group). All participants completed reading and writing tests (Work Attack, Word Identification and Comprehension- from The Wookcock Reading Mastery, and spelling from the WRAT), psychoacoustic tasks (Tone detection, backward detection masking, frequency discrimination, gap detection, intensity discrimination, formant discrimination, frequency discrimination under backward masking, interval discrimination, tone-sequence identification) and intelligence measures (Matrix Analogies Test and Wookcock-Johnson Tests of Cognitive Ability). Results found that there were no poor readers in the control group and few good readers in the CHRD group, indicating that reading difficulties in childhood carry into adulthood. This study also found that performance on auditory processing tasks was correlated with reading and spelling scores. Poor readers were found to have impaired performance on auditory tasks. This is consistent with the hypothesis that deficits in auditory processing underlie impairments in reading and spelling. From their findings the authors proposed that good readers experience accurate sound representation, which facilitates the encoding of acoustic patterns into phonological representations. The high-quality encoding that occurs in proficient readers' allows for the automatic translation of phonological codes into written language, with little or no effort. They concluded that poorer readers', however, experience degraded and abnormal representation of the phonological parts of speech, i.e. they have auditory processing deficits. This causes difficulty in encoding and as a result translating written words into spoken language is difficult (Ahissar, et al., 2000).

Our ability to recognise, understand and discriminate auditory information is directly linked to our listening, comprehension and learning capacity. When the auditory skills required for efficient auditory processing are impaired, acoustic signals are misrepresented in the auditory cortex and are therefore not accurately interpreted by the brain. Inaccurate interpretation results in impaired phonological representations, which in turn lead to weak phonological awareness. It is this phonological awareness that is a fundamental skill for reading. Research has found that majority of individuals

with reading disorders also have auditory processing disorders. Auditory processing disorders result in the abnormal processing of auditory information. It is this auditory processing deficit that is believed to cause poor sound encoding, resulting in the impaired translation of written text to phonological codes. Efficient and accurate phonological representations are essential for reading success. If these are inaccurate and impaired as a result of an auditory processing skills deficit, phonological awareness will be negatively impacted causing reading difficulties or disorder. The present literature confirms the strong correlations between auditory processing disorders, deficits in phonological awareness and reading difficulties.

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