Why do Some Children Struggle with Reading? Is there a Relationship between Dyslexia and Auditory Processing Disorder (APD)?

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English is an alphabetic language, meaning that the written symbols of the language are closely related to the *phonological system*. The phonological system of a language may be described as the underlying shared system of speech sounds that we use to convey meaning. Alphabetic languages rely on a process of converting this spoken, phonemic code into a visual, orthographic code, which is then converted back to speech when reading. Since the orthography of alphabetic languages such as English is based on the phonological system, an understanding of the relationship between sound and letter patterns facilitates the "breaking of the code" in written language. This process is called decoding, and allows the reader to successfully read unfamiliar words and develop visual word recognition skills.

Decoding allows children to access the thousands of words they have already heard but never seen in written form. Despite being an alphabetic language, English does not have a consistent orthography (like Finnish or Italian, for example) in which every *phoneme,* or sound, in the language has a corresponding *grapheme* (a letter or group of letters representing one phoneme), with some graphemes representing more than one phoneme (compare "s**ch**ool" with "**ch**ip"), and some phonemes

represented by more than one grapheme (consider “h**er**, b**ir**d” and “t**ur**n”). Nevertheless, most of English spelling is based on the phonology of the language. Approximately 50% of English words can be spelt correctly with grapheme-phoneme conversions alone, and a further 36% can be spelt with the exception of one grapheme-phoneme inconsistency (Hanna, 1966), making strong decoding ability a very powerful tool for self-teaching.

Decoding skills are crucial when reading unfamiliar *regular words* with consistent sound-symbol relationships (such as the words “strips”, “representing” and “hippopotomonstrosesquippedaliophobia”) as well as *non-words* - made up words that consist of permissible spelling patterns but have no meaning (such as the words “scritten”, “borker” and “vasster”). Decoding skills are not so useful when reading unfamiliar *irregular words* (words that do not contain regular grapheme-phoneme patterns, such as the words “bureau”, “yacht” and “colonel”).

While most children acquire decoding ability without too much difficulty, a significant proportion of the population (around 20%) have great difficulty in developing adequate decoding skills. Poor decoding skills lead to difficulty in reading unfamiliar words, and poor self-teaching. An overwhelming body of research suggests that in general, poor readers have poor decoding skills and that better readers have better decoding skills. “Yes, but what about comprehension skills? There is a lot more to reading than decoding!” I hear you say. Of course, comprehension skills are crucial in the reading process, and the importance of developing language skills cannot be underemphasised. Indeed, research suggests that good decoders with poor reading comprehension also have poor listening comprehension skills and therefore are likely to have underlyng language difficulties. However, research also suggests that a large proportion of children with reading

comprehension difficulties are poor comprehenders due to decoding difficulties (see Vellutino, Fletcher, Snowling, & Scanlon, 2004 for a review). In addition, the ability to read irregular words depends highly on reading experience and decoding ability (Sprenger-Charolles & Serniclaes, 2006).

So, the bottleneck for the majority of poor readers is related to poor decoding skills. Decoding difficulties are a hallmark of *dyslexia*. A large body of behavioural and neuro-imaging evidence suggests that the core deficit in children with dyslexia is impairment in *phonological processing skills*, which may be defined as an individual's understanding of the sound structure of language. This phonological processing deficit leads to impairment in the ability to map the written representations of the language onto its sound structure, resulting in poor decoding, poor self-teaching and poor reading ability.

Researchers have devised a number of phonological processing tasks which are thought to tap into the underlying phonological processing deficit in individuals with dyslexia. *Phonological awareness* tasks (which involve assessing the ability to identify, reflect upon and manipulate the sound units of language) and in particular *phonemic awareness* tasks (which involve evaluating awareness of individual sounds in words) are consistently found to be significantly more difficult for individuals with dyslexia compared with individuals without reading difficulties. *Phonological memory* tasks (which assess an individual's ability to recall what was just said) and *rapid naming* tasks (in which the individual is required to name a series of objects, colours, numbers or letters as quickly as possible) also consistently reveal relative weaknesses in individuals with dyslexia. In addition, at least a sub-group of individuals with dyslexia demonstrate speech perception difficulties, with some

studies even suggesting that speech perception measures at infancy are a highly predictive indicator of later reading acquisition (e.g. Lyytinen et al., 2004).

These observations have led researchers to propose the “phonological deficit hypothesis”, which posits that phonological processing tasks depend upon the strength of *phonological representations*: the brain’s representations of the sound structure of language. These phonological representations are thought to be weaker, or ‘less specific’ in individuals with dyslexia. But what could cause weak phonological representations? There is evidence to suggest that the phonological system becomes increasingly sensitive to phonemic differences between words as vocabulary size grows (e.g. Ziegler & Goswami, 2005), suggesting a close relationship between vocabulary skills and phonological processing, and leading some researchers to suggest that phonological processing weaknesses stem from weaker vocabulary skills in individuals with dyslexia. There is also evidence to suggest that in at least a sub-population of children with reading difficulties, phonological processing difficulties may be related to an impairment in the perception of low-level (non-speech) auditory signals, which some authors have suggested could interfere with the brain’s ability to form precise representations of the sounds of language (e.g. Tallal, 1980). While this is a contentious and disputed hypothesis, recent brainstem timing studies have again highlighted the potential role of auditory processing in reading difficulties, with researchers finding significant correlations between low-level auditory processing and reading ability (Banai et al., 2009). To date, however, the effect of auditory processing deficits on reading development has not been clearly established.

Surprisingly, there has been a paucity of research investigating the phonological processing and reading abilities of children diagnosed with APD

(Auditory Processing Disorder). APD is diagnosed when an individual has significant difficulty in identifying or discriminating between sounds despite normal peripheral hearing, and has been defined as, “A deficit in the processing of information that is specific to the auditory modality” (Chermak, 2001, p. 10). APD offers a potentially invaluable opportunity to study the impact of auditory processing difficulties on reading ability. The handful of studies investigating reading skills in children with APD suggest that there may be a relationship between APD and reading difficulties. For example, in her doctoral study investigating the receptive language and reading skills of children with APD, my colleague Dr. Stephanie Mallen sought to match the reading age score of 21 children diagnosed with APD to 21 ‘average readers’ in order to analyse reading error patterns. Interestingly, it was discovered that the matched ‘average’ group were also significantly younger (by a mean of 13 months) than the group with APD, indicating that the reading accuracy skills of the APD group were significantly poorer than the average reader group (Mallen, 2010). Meanwhile, Dawes and Bishop (2010) found that 52% of children with APD (N=25) would fit a diagnosis of dyslexia or specific language impairment (SLI), or both.

In my own doctoral study (Rajkowski, 2012), I evaluated numerous skill areas thought to be related to reading development in a group of 57 children aged between 8;0 and 11;0. The group consisted of three sub-groups: 19 control children (the CON group), 19 children diagnosed with dyslexia (the DYS group) and 19 children diagnosed with APD (the APD group). The three groups were matched for age and non-verbal IQ, allowing for a comparison of skills between the three groups. Results revealed that the APD group showed significantly poorer phonological awareness, phonological memory and rapid naming skills compared to the CON group. The APD and DYS groups showed similar phonological processing and vocabulary skills (with

no statistically significant differences in abilities between the APD and DYS groups), suggesting that significant phonological processing difficulties are a feature of APD. This result was consistent with the reading assessment, which revealed that the APD group also had significantly poorer reading ability (for regular, irregular and non-words) than the CON group, indicating that the APD group had significant reading difficulties. The APD and DYS groups demonstrated the most significant relative weaknesses in their ability to read non-words, consistent with the prediction that the two groups would have specific and significant difficulties with decoding skills. Despite being significantly poorer than the average group, the results also showed that the APD group were significantly better at reading compared with the DYS group, with the DYS group demonstrating the poorest decoding and grapheme knowledge of the three groups. The results suggested that while children with APD may not be as reading impaired as children with dyslexia, children with APD are likely to have significant reading difficulties compared with 'average' children. My research suggests that as for the children with dyslexia, these reading difficulties are characterised by deficits in phonological processing, decoding ability and grapheme knowledge.

So is there a relationship between dyslexia and APD? The results of my study suggest that children with APD are at significantly greater risk of phonological processing and associated reading difficulties compared with 'average' children. While more research is needed, it is possible that these difficulties are related to APD interfering with the formation of phonological representations (this possibility is explored in detail in my thesis). It is important for teachers to be aware of the potential connection between APD and dyslexia, and for audiologists performing APD assessments to be mindful of the likelihood of reading difficulties in children

with APD so they can refer on accordingly. Finally, current research and my own study highlight the importance of assessing and strengthening phonological processing, grapheme-phoneme knowledge and decoding skills for all children. The evidence is clear and consistent with the 2004 Australian Government Inquiry into the Teaching of Reading: students will benefit most from methods of teaching reading that explicitly teach the relationship between phonology and orthography in language, helping them to 'break the code' and master self-teaching.

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