



Dyslexia as a multi-deficit disorder: Working memory and auditory temporal processing

Leah Fostick^{a,*}, Hadas Revah^b

^a Department of Communication Disorders, Ariel University, Israel

^b Department of Psychology, Ariel University, Israel

ARTICLE INFO

Keywords:

Dyslexia

Working memory (WM)

Auditory temporal processing (ATP)

ABSTRACT

Dyslexia is difficulty in acquiring reading skills despite adequate intelligence and sufficient reading opportunities. Its origin is still under debate. Studies usually focus on a singular cause for dyslexia; however, some researchers argue that dyslexia reflects multiple deficits. Two of the abilities under investigation in dyslexia are working memory (WM) and auditory temporal processing (ATP). In order to better evaluate the relative roles of WM and ATP in dyslexia, in the present study, we tested the contribution of WM and ATP to different types of reading performance and phonological awareness in dyslexia, using a multidimensional approach. Seventy-eight adults with dyslexia and 23 normal-reading adults performed WM and ATP tasks, as well as reading and phonological awareness tests. Readers with dyslexia showed poorer performance on all tests. Both WM and ATP were significant predictors of reading performance and phonological awareness among participants with dyslexia. Dividing participants with dyslexia according to their performance level on WM and ATP tasks revealed group differences in reading and phonological awareness tests. Both WM and ATP contribute to dyslexia, and varying levels of difficulties in both of these abilities are observed among this population. This is strong evidence in favor of the multi-deficit approach in dyslexia, and suggests that researchers should consider this approach in future studies of dyslexia.

1. Introduction

Developmental phonological dyslexia is a neuro-cognitive disorder described as a difficulty in acquiring reading skills, despite adequate intelligence and sufficient reading opportunities (Shaywitz, 1996; Tanaka et al., 2011; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Dyslexia has a strong genetic basis that is reflected in regions of the genome, mainly on chromosomes 6 and 18, which might contain inherited variants that cause reading disability (Francks, MacPhie, & Monaco, 2002). It appears in > 10% of school children (American Psychiatric Association, 1994; Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992; Wybrov & Hanley, 2015) and is often characterized by poor word identification and letter-sound phonological decoding (Adams, 1990; Perfetti, 1992; Stanovich, 1991; Vellutino et al., 2004). These difficulties are reflected in difficulties in phonological awareness and processing shown by readers with dyslexia (Dandache, Wouters, & Ghesquière, 2014; Layes, Lalonde, & Rebaï, 2015; Pennington, Van Orden, Smith, Green, & Haith, 1990).

1.1. Theories of dyslexia

Over the last few decades, various theories have tried to identify the origin of dyslexia. The phonological theory argues that dyslexia stems from deficits in the ability to identify, store, and retrieve the sounds of the language. These sounds, phonemes, are the basic components of a word. According to the phonological theory, the ability to read accurately is based on appropriate awareness of these features, also called phonological awareness (Berent, Vuknin-Nusbaum, Balaban, & Galaburda, 2013; Mayringer & Wimmer, 2000; Mody, Studdert-Kennedy, & Brady, 1997; Vellutino et al., 2004); a deficit in phonological awareness causes disruption in learning to appropriately associate grapheme (the shape of the letter) to phoneme (the sound of the letter) (Auclair-Ouellet, Fossard, St-Pierre, & Macoir, 2013; Blachman, 2000; Share & Stanovich, 1995; Snowling, 1981; Snowling, 2000; Tholen, Weidner, Grande, Amunts, & Heim, 2011).

Other researchers agree that readers with dyslexia show these phonological difficulties, but argue that these symptoms stem from a more basic deficit. Accordingly, they suggest that the origin of dyslexia may be related to: poor visual information processing for rapid

* Corresponding author at: Department of Communication Disorders, Ariel University, Ariel 40700, Israel.
E-mail address: leah.fostick@ariel.ac.il (L. Fostick).

sequential stimuli (Lovegrove, Bowling, Badcock, & Blackwood, 1980; Schaadt, Männel, van der Meer, Pannekamp, & Friederici, 2016; Stein & Walsh, 1997; Wang et al., 2014); a deficit in the cerebellum, which supports reading (Nicolson & Fawcett, 1990; Nicolson, Fawcett, & Dean, 2001; Stoodley & Stein, 2013); magnocellular deficiency, which creates low-level visual deficits in sensory temporal processing (Fisher, Chekaluk, & Irwin, 2015; Gori et al., 2015; Stein, Talcott, & Witton, 2001; Stein & Walsh, 1997); anchoring problems, which cause readers with dyslexia to fail to benefit from stimulus-specific repetitions (Ahissar, 2007; Banai & Ahissar, 2010; Oganian & Ahissar, 2012; Wijnen, Kappers, Vlutters, & Winkel, 2012); poor working memory, which causes difficulties in retaining and manipulating information (Banai & Ahissar, 2004; Garcia, Mammarella, Tripodi, & Cornoldi, 2014; Gathercole & Pickering, 2000; Gathercole, Tiffany, Briscoe, & Thorn, 2005; Zhao, Yang, Song, & Bi, 2015); or difficulties in processing auditory temporal information (Ben-Artzi, Fostick, & Babkoff, 2005; Farmer & Klein, 1995; Fostick, Bar-El, & Ram-Tsur, 2012a, 2012b; Heim, Freeman, Eulitz, & Elbert, 2001; Keen & Lovegrove, 2000; Meyler & Breznitz, 2005; Reed, 1989; Tallal, 1980).

Each of these possible mechanisms, and more not mentioned here, generate different diagnostic and remediation tools to address the theorized deficit. However, the variance among readers with dyslexia is large: for each mechanism, there are readers with dyslexia that show the deficit predicted, but many others that do not. In the same vein, while there are many training programs for those with dyslexia, each seems to help some readers and not others. The insufficiency of each individual explanatory framework might either suggest that the real core deficit of dyslexia is yet to be found, or that the approach of looking for one single deficit is not suitable.

1.2. Working memory and auditory temporal processing

The current study focuses on two of the explanatory frameworks mentioned above: working memory and auditory temporal processing. Each of these abilities, separately, has received much attention in the literature and has been found related to the phonological difficulties described by the phonological theory. However, they represent different potential “core deficits” in dyslexia. Moreover, some studies suggest that WM and ATP are not independent factors for dyslexia, but actually may be related to each other (e.g., Banai & Ahissar, 2004). The potential connection between these mechanisms is the focus of the current study.

Working memory (WM) is thought to include a system that is responsible for maintaining verbal and auditory information, and it supports long-term phonological representations of language (Baddeley, Gathercole, & Papagno, 1998; Gathercole et al., 2005; Schwarb, Nail, & Schumacher, 2016). Readers with dyslexia often show poor short-term memory for words and difficulty in performing phonological manipulation that requires maintenance of phonological information while it is being changed (Banai & Ahissar, 2004; Gathercole et al., 2005; Gathercole & Pickering, 2000; Verhagen & Leseman, 2016). Readers with dyslexia have also been found to show deficient performance in WM tests, such as the forward and backward digit span, short-term retention of words through interfering stimuli and task switching, repetition of tapping patterns of increasing lengths, serial comparison, recognition, and recall of words and non-words (Banai & Ahissar, 2006; Brambati et al., 2006; Garcia et al., 2014; Gathercole & Pickering, 2000; Jeffries & Everatt, 2004; Ram-Tsur, Faust, & Zivotofsky, 2006, 2008; Zhao et al., 2015). This difficulty in maintaining and manipulating information can be related to their difficulty in acquiring reading skills.

Auditory temporal processing (ATP), on the other hand, reflects an individual's ability to process rapid sounds (Babkoff & Fostick, 2013; Fostick & Babkoff, 2013). According to the ATP deficit theory for dyslexia, difficulty in processing rapid stimuli disrupts the appropriate encoding of speech sounds necessary for good phonological representations and reading acquisition (Farmer & Klein, 1995; Fostick

et al., 2012a; Goswami, Fosker, Huss, Mead, & Szucs, 2011; Heim et al., 2001; Keen & Lovegrove, 2000; Meyler & Breznitz, 2005; Reed, 1989; Tallal, 1980). Indeed, readers with dyslexia show poorer performance in all kinds of ATP tasks, including those that involve both speech and non-speech sounds (Ahissar, Protopapas, Reid, & Merzenich, 2000; Ben-Artzi et al., 2005; Breier et al., 2001; Fostick et al., 2012a, 2012b; Fostick, Babkoff, & Zukerman, 2014; Fostick, Eshcoli, Shtibelman, Nechemya, & Levi, 2014; Goswami, 2011; Goswami et al., 2011; Ramus et al., 2003; Reed, 1989; Tallal, 1980). These findings suggest that poor ATP might be related to difficulties in acquiring reading skills.

A close inspection of the literature reveals a debate regarding the roles of WM and ATP in dyslexia. Both abilities relate to problems in perceiving and maintaining auditory information as the main cause of dyslexia (Banai & Ahissar, 2004, 2006; Fostick et al., 2012a, 2012b; Reed, 1989; Tallal, 1980). Some researchers have suggested that the deficit in auditory processing inherent in ATP is secondary to the deficit in working memory (e.g., Banai & Ahissar, 2004). According to this hypothesis, a deficit in working memory underlies the difficulties that readers with dyslexia exhibit in auditory temporal resolution tasks, since it reduces access to stored information (i.e., speech sounds and phonological representations).

Some studies measured WM and ATP among the same participants with dyslexia. These studies have shown them both to be poor among readers with dyslexia (Banai & Ahissar, 2006; Ben-Artzi et al., 2005; Chait et al., 2007; Fostick et al., 2012a; Lallier, Thierry, & Tainturier, 2013; Ziegler, Pech-Georgel, George, & Lorenzi, 2009). However, although both abilities were found to be related to dyslexia, it is not clear whether they have the same amount of contribution to dyslexia, or whether one of these abilities is more dominant than the other. Previously, we showed that, in a regression analysis conducted on a group of adults with dyslexia, WM and ATP are *independent* predictors for reading. Each predicted 24–34% of the accuracy in the Reading Meaningful Words task, when controlling for their shared variance (Fostick et al., 2012b). These findings argue against the hypothesis that WM is responsible for the ATP deficit by suggesting that both deficits contribute independently to poor reading skills. This will be discussed further below.

1.3. Dyslexia as a multi-deficit disorder

Most studies in the existing literature have focused on theories suggesting a singular cause for dyslexia (e.g., Ben-Artzi et al., 2005; Fostick et al., 2012a; Garcia et al., 2014; Zhao et al., 2015). However, as we suggested earlier, this approach fails to find one theory that accommodates the variability among readers with dyslexia. Other research has argued that dyslexia is the result of several degraded processes (e.g., Ramus et al., 2003; Reid, Szczerbinski, Iskierka-Kasperek, & Hansen, 2007; Wright, Bowen, & Zecker, 2000), often attributing dyslexia to a combination of auditory and visual processing deficits (such as the double-deficit hypothesis; Nelson, Lindstrom, & Foels, 2015; Wolf & Bowers, 1999).

Among the degraded processes suspected of playing a dynamic role in dyslexia are working memory (WM) and auditory temporal processing (ATP). It is not clear, however, how WM and ATP deficits combine to affect reading ability, and whether they both affect all readers with dyslexia to the same extent. In our previous work on WM and ATP, both were found to have similar contribution to reading (Fostick et al., 2012b). However, in that study, only the Reading Meaningful Words task was used, which leaves the unanswered question of whether this equal contribution would be maintained during tests that elicit different processing demands. Some tasks, for instance, involve manipulation of phonemes (e.g., Spoonerism and Pig Latin) that may rely more heavily on WM, which controls the maintenance and manipulation of information. Other tasks that involve perception of the sound sequence (e.g., Reading Meaningful/Nonsense Words) may depend more on ATP. Therefore, employing a multi-factor approach involving WM and ATP,

Download English Version:

<https://daneshyari.com/en/article/7276819>

Download Persian Version:

<https://daneshyari.com/article/7276819>

[Daneshyari.com](https://daneshyari.com)