View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by University of Essex Research Repository

Is there just one dyslexic reader?

J Richard Hanley (PhD)

Address for correspondence

Prof. J. Richard Hanley

Department of Psychology

University of Essex

Colchester CO4 3SQ

UK

EMAIL rhanley@essex.ac.uk

Abstract

Purpose of Review. It is generally agreed that there are individual differences in the severity of the reading deficit in dyslexia. The purpose of this review is to discuss whether recent research strengthens claims that there are also qualitative differences in the *type* of reading impairment that individual dyslexic children experience.

Recent Findings. Recent research suggests that surface dyslexia exists in larger numbers than has previously been assumed and that different subtypes of surface dyslexia exist in English as well as in Hebrew. Bilinguals with surface dyslexia in English also show the hallmarks of surface dyslexia when reading a more transparent orthography. The developmental reading impairments that have been observed in children with phonological dyslexia and in children with letter position dyslexia can also be found in several different orthographies and are quite distinct from those seen in surface dyslexia.

Summary. Surface dyslexia, phonological dyslexia and letter position dyslexia represent qualitatively different types of developmental reading impairments and can all be seen in both opaque and more transparent alphabetic orthographies.

Key Words Surface dyslexia . Letter position dyslexia . Phonological dyslexia.

Introduction

Dyslexia is a developmental impairment that makes it difficult for children to learn to read aloud and understand written words. It is not a disorder that should be thought of in categorical terms. This is because there because there is no agreed cut-off between normal and dyslexic reading [1] and because there are clear individual differences in the severity of the dyslexic impairment that an individual child can experience [2].

It is now generally accepted [3-5] that these differences in severity are to a considerable extent determined by the nature of the compensatory skills that are available to an individual child. This conclusion has emerged from the results of important longitudinal research that has examined the reading development of children from families with a genetic risk of dyslexia [4-5] Impaired reading performance was strongly linked to poor performance on tests of letter knowledge, phoneme awareness and rapid automatized naming. However, children with good language skills around the time of school entry were less likely to be categorized as dyslexic when they reached eight years of age. Children with poor executive skills at 4.5 years were more likely to be later categorized as dyslexic. It therefore appears that even when child has a developmental phonological impairment, the level of his or her executive skills, motor skills, attentional skills and general language skills are likely to determine the severity of the reading impairment that he or she will experience [4-5].

It is also accepted that there are individual differences in the type of reading impairment that different children experience. For example, some children find it difficult to read because they experience visual stress when looking at words on the page of a book [6]. In many cases, these problems can be ameliorated by

placing colored overlays on top of the text. Other children experience comprehension deficits [7]. This makes it difficult for them to understand written text even though they can read aloud single words without any apparent impairment. Developmental impairments such as these profoundly affect children's reading performance but they do not represent different forms of dyslexia because they are not the result of a primary problem in learning to read and spell single words.

There is much less agreement as to whether the nature of the core dyslexic deficit can itself differ qualitatively from one child to another. Indeed, the issue of whether there are different types of developmental dyslexia is one of the most contentious and divisive in the literature on the acquisition of literacy. At one end of the debate, a recent review paper [8] argued for the existence of a multitude of different types of impairment that can impede children's ability to learn to read words. Such an approach is similar to that adopted in the study of acquired dyslexia where the existence of different types of dyslexia provokes no controversy whatsoever. It was claimed [8] that there are "peripheral" developmental dyslexias such as letter position dyslexia, letter identity dyslexia, neglect dyslexia, attentional dyslexia and visual dyslexia that affect early stages of visual/orthographic processing. It is also claimed [8] that there are "central" developmental dyslexias such as phonological dyslexia, surface dyslexia and deep dyslexia that affect later stages of processing. Their review [8] provides detailed descriptions of the symptoms of all of these apparently distinct forms of single-word reading disorders.

At the other extreme are those who define dyslexia as the consequence of a phonological impairment. According to one influential definition [9], for example,

"dyslexia is a specific form of language impairment that affects the way in which the brain encodes the phonological features of spoken words." A more recent review [3] claimed that dyslexia "is a language-based disorder whose primary underlying deficit involves problems in phonological processing." It has even been claimed that a phonological impairment should be part of the definition of dyslexia because it justifies the use of phonological skills training to ameliorate reading impairments in dyslexia [2]. Once a phonological processing deficit becomes part of the definition of dyslexia, then it follows that individuals with no apparent phonological impairment either do not have dyslexia or did at one time have a phonological problem that can no longer be detected. In response, a strong case has been made [10] that the complexity and heterogeneity of dyslexia is incompatible with this claim.

The current review steers a path between these extremes by focusing on research investigating just three dyslexic subtypes: letter position dyslexia, surface dyslexia and phonological dyslexia. This is because all three subtypes have been observed in several different orthographies and because there has been notable progress in our understanding of all of them in the last few years.

Incidence of Surface dyslexia and Phonological dyslexia in English.

In English, *surface* dyslexia is characterized by difficulties in reading words (e.g. *pint*) whose pronunciation cannot be predicted correctly from their spelling (irregular words) [1, 8]. The ability of surface dyslexics to read aloud word-like letter strings (e.g. *nolt*) is relatively well preserved. So is their performance on tests of phonological awareness. Conversely, *phonological* dyslexia is a selective difficulty in reading aloud nonwords despite preserved ability to read familiar written words. Phonological dyslexics also perform poorly on phonological

awareness tests. Phonological and surface dyslexia have long been observed in single case studies of carefully selected individuals [1, 8]. Surface and phonological dyslexia can also be observed amongst groups of people with dyslexia [11-13]. These subgroups appear to be relatively stable longitudinally [14].

It must be acknowledged that most individuals with dyslexia in English-speaking countries generally experience difficulties with reading and spelling both irregular words and nonwords. Moreover, even amongst the minority with selective reading deficits, the dissociation is often relative rather than absolute. For example, *relative* phonological dyslexics dyslexics are impaired at reading both nonwords and irregular words but are more impaired at reading nonwords than irregular relative to controls. Cases of pure surface and phonological dyslexia are much rarer. The phonological awareness deficit appears to be more profound in relative than in pure phonological dyslexia [13].

The existence of these two types of dyslexia is consistent with claims that a different reading route is responsible for processing nonwords from the route that processes words with atypical spelling-sound correspondences [15-17]. In the triangle model of reading, irregular words are read primarily by an orthography-semantics pathway that fails to develop normally in children with surface dyslexia [18]. In the DRC model [15], there is a lexical route that can activate the pronunciation of irregular words directly from their representation in an orthographic lexicon. Nonwords and regular words are read by a separate nonlexical pathway that does not develop normally in phonological dyslexia. For a variety of reasons, this pathway processes words relatively slowly [17].

All accounts of dyslexia in English accept the existence of large numbers of children with a disproportionately severe phonological deficit and acknowledge

that phonological dyslexia is a genuine developmental reading deficit. According to the triangle model, the impairment is to the phonological units themselves [19]. Our understanding of the nature of the phonological deficit that these children encounter is becoming increasingly refined (3, 20). An examination of the phonological skills of a group of such children revealed significantly impaired performance on a test of grapheme-phoneme knowledge and nonword spelling relative to controls. They did not differ significantly from controls at nonword repetition, phoneme blending or picture naming [20].

There is much less agreement, however, as to the prevalence of surface dyslexia. When the reading skills of dyslexic children are compared with children of the same chronological age then substantial numbers of surface and phonological dyslexics emerge. When dyslexics and controls are matched for reading age, however, the incidence of surface dyslexics is reduced [21-22]. Consequently, it has been claimed that the surface dyslexic profile represents a developmental delay whereas phonological dyslexia reflects a genuine developmental deviance in reading acquisition [21-22]. However, a more recent study [13] with a larger sample size showed a different pattern; the surface dyslexics did perform significantly worse on a test of irregular word reading than controls with whom they were matched for reading ability.

There has been a growing realization in recent years that the use of RA controls is not optimal when estimating the incidence of surface dyslexia [20, 23-25]. The main problem is that the tests of real word reading that are used to estimate RA contain many irregular words. So if one matches surface dyslexics with children of equivalent reading age in terms of the number of real words that they can read, it will be difficult to observe differences between the surface

dyslexics and controls in terms of the number of irregular words that they read correctly. This is because the matching process will have already reduced differences in irregular word reading performance between the surface dyslexics and controls. When the incidence of surface dyslexia was instead assessed by comparing dyslexic performance with a control group who were matched in terms of their score on a test of nonword reading, then more substantial numbers of surface dyslexics were observed [26].

In summary, two studies now exist in which the pattern of irregular word reading performance demonstrated by surface dyslexics was not observed in younger normal readers with whom they were matched for nonword reading [26] or overall reading ability [13]. Such differences strongly suggest that surface dyslexia represents a genuine developmental reading disorder.

Surface dyslexic subgroups.

In a landmark paper [27], Friedmann and Lukov documented the existence of different surface dyslexic subtypes in readers of Hebrew. Some individuals with surface dyslexic were unable to distinguish real words from nonwords on an orthographic lexical decision test, consistent with an impairment to the development of the orthographic lexicon itself. Friedmann and Lukov referred to this condition as *input* surface dyslexia. Poor lexical decision has also been reported in other studies of children with selective problems in reading aloud irregular words [20]. However, some of Friedmann and Lukov's surface dyslexics performed well at lexical decision even though they showed poor performance on a test that required access to the semantic system from written words. Friedmann and Lukov referred to this condition as *orthographic output* surface dyslexia and argued that in these cases the orthographic lexicon had developed normally. They

claimed that it is the connections from the orthographic lexicon to the semantic system and from the orthographic lexicon to the phonological lexicon have not developed normally in orthographic output surface dyslexia.

An additional type of surface dyslexia was recently reported [28] in which individuals showed preserved access to the meanings of written words but poor picture naming. The general word finding difficulty shown by these individuals suggests that their inability to read irregular words aloud is caused by a more general language processing problem in which there is impaired development of the links from the semantic system to the phonological system.

Friedmann and her colleagues [27-28] observed these differences in a semitic language (Hebrew) where the orthography to phonology cues are relatively limited. It is now clear that these three different types of surface dyslexia can also be found in less opaque orthographies than Hebrew such as English and Greek [29]. For example, some individuals with surface dyslexia in English could distinguish written irregular words from nonwords and could access the meaning of irregular written words even though they could not read them aloud. Furthermore these individuals could spell accurately the names of pictures that were irregular words despite being unable to spell them to dictation. Clear parallels between the reading and spelling performance of these individuals indicated that these subtypes could be applied equally effectively to spelling impairments in surface dysgraphia. The results were also consistent with the claim [30] that the same orthographic lexicon is used for both reading and spelling, and that the same neurophysiological substrate(s) supports both learning to read and learning to spell familiar words.

Distal Causes of Surface dyslexia

It is clear that progress [27-29] has been made in identifying three different proximal causes of surface dyslexia (impaired development of the orthographic lexicon, impaired development of its connections to the semantic system and impaired access to the phonological lexicon during speech production). Less progress has been made in understanding what the distal cause of surface dyslexia might be. It is hard to see how there could be a primary deficit in developing an orthographic lexicon in surface dyslexia because only a minority of the human beings who have ever lived have had the opportunity to become literate [1]. It has instead been suggested that the distal cause of surface dyslexia is limited exposure to print [22], but recent evidence [13] does not support this conjecture. One possible reason for the lack of progress is that the surface dyslexic subgroups might be associated with distinct distal causes. For example, even if some individuals with surface dyslexia suffer from a general visual memory deficit [31], it is hard to see how that could be the distal cause of surface dyslexia in an individual whose reading problems appear to be associated with a developmental spoken-word production impairment [28-29].

In the triangle model [18, 32], reading is scaffolded onto more basic knowledge systems. In order to learn to read, it is necessary to associate processing units that are sensitive to differences in the orthographic structure of words (orthographic units) with more basic general knowledge systems relating to vision, phonology, and semantics [18]. Surface dyslexics generally perform worse than phonological dyslexics on orthographic learning tasks where associations must be remembered between pictures and written nonwords [33]. This raises the possibility that the distal cause of poor orthographic learning in many surface dyslexics is a more general impairment in learning new associations. It is known

that dyslexic children perform poorly at paired associate learning [34], but a recent case study [35] suggests that a paired associate learning deficit applies more to surface than phonological dyslexia. The performance of a phonological (PD) and a surface dyslexic child (SD) was compared on different paired associate learning tasks. In one of these tasks, these two individuals were asked to associate a written nonword with a visual shape or to associate two visual shapes with each other. The other task required the child to learn the meaning of an unfamiliar letter string when it was presented in the context of a sentence ("This hairy monster is called a *vade*…"). Despite superior phonological awareness skills, SD performed worse on all of these learning tasks than PD. This study has limitations because of the number of its participants but a general paired associate learning deficit is an important claim about a distal cause of surface dyslexia that a larger scale project should investigate in the future.

Surface and phonological dyslexia in more transparent orthographies

Researchers have identified surface dyslexia in English [11] and French [36] by examining the accuracy of irregular word reading. In more transparent alphabetic orthographies such as German, Greek, Italian, and Spanish, words with atypical spelling-sound correspondences are virtually non-existent and almost all words can be read accurately by applying typical letter-sound associations.

In some transparent orthographies, surface dyslexia has been identified by looking for errors in applying stress when reading words aloud. This is because some words in orthographies such as Italian and Filipino have atypical stress patterns that are not marked in the orthography. It follows that generating the appropriate stress pattern for a written word with less typical stress requires access to its lexical entry. It has been shown that Italian dyslexic children make

more stress errors when reading low frequency words than typically developing children and tend to assign to them the default stress pattern [37]. However, these dyslexics did not fit the criteria of surface dyslexia because they seemed to suffer from both a phonological and a lexical reading impairment. A case study of a Filipino boy with dyslexia [38] showed that he read words with typical stress patterns as accurately as controls, but made many more stress errors than controls when reading Filipino words with atypical stress patterns. He regularized the pronunciation of many of these words by incorrectly placing the stress on the penultimate syllable (the default Filipino stress pattern). Since he also read nonwords as accurately and quickly as controls and performed well on tests of phonological awareness, this child represented a clear case of developmental surface dyslexia in a transparent orthography.

Another possibility is that surface dyslexia in transparent orthographies can be detected by slow reading of familiar words [25, 39]. This is because longer reading times may reflect an overreliance on the slower phonological/nonlexical route, consistent with impaired development of the lexical or semantic reading route. In support of this claim, subgroups of Greek dyslexic children have been identified who read familiar words relatively slowly. Consistent with surface dyslexia, these individuals have unimpaired phonological skills and accurate reading of nonwords [25, 40-41]. These studies also identified additional children who performed quickly and accurately when reading familiar words but who made a relatively large number of errors when reading and spelling nonwords, consistent with developmental phonological dyslexia. These findings confirm that individuals with pure surface and phonological dyslexia can be observed in both transparent and opaque alphabetic orthographies. A subgroup of dyslexics with

poor phonological skills who read real words accurately and quickly appears to undermine claims that slow reading in transparent orthographies is the hallmark of a phonological impairment [42].

A third way to investigate the incidence of surface dyslexia in transparent orthographies is to examine the spelling of words with atypical sound-spelling correspondences. Several shallow orthographies are less transparent for writing than for reading and contain many words of this kind. A number of studies show that dyslexic readers of Greek who read familiar words slowly are also poor at spelling words with atypical sound-spelling correspondences [25, 39-40]. German-speaking dyslexics [41] have been also shown to have particular problems in spelling irregular German words consistent with the view that dyslexia in German is associated with a lexical rather than a phonological impairment. Further evidence for a lexical impairment emerged when the German-speaking dyslexics found it difficult to distinguish correctly spelled words from pseudohomophones on a written lexical decision task but were able to distinguish pseudohomophones from phonologically incorrect spellings. It was concluded that many German dyslexics experience a reading impairment more closely resembles surface than phonological dyslexia [41].

Is it the case that the underlying impairment that produces slow reading of familiar words by dyslexic children in transparent orthographies produces inaccurate reading of irregular words in English? A study of seven dyslexics who were bilingual in English and Greek investigated this issue [40]. Their slow reading and impaired spelling accuracy of Greek familiar words satisfied the criteria for Greek surface dyslexia. When asked to read words with atypical grapheme-phoneme correspondences in English (their second language), accuracy

was also severely impaired. A co-occurrence was also observed between impaired spelling of words with atypical phoneme-grapheme correspondences in English and Greek. These co-occurrences provide strong evidence that surface dyslexia genuinely exists in Greek and that slow reading of real words in Greek reflects the same underlying impairment as that which produces inaccurate reading of irregular words in English. Two further individuals were observed with impaired reading and spelling of nonwords in both languages, consistent with developmental phonological dyslexia in both Greek and English. This outcome indicates that the foundation skills that allow children to learn to read and spell familiar words are the same in Greek as in English, and that the foundation skills that allow children to read and spell unfamiliar words are the same in Greek as in English. Such an outcome provides evidence that the neurophysiological substrate(s) that support the lexical/semantic and the phonological pathways that are involved in reading and spelling are the same in both Greek and English.

In conclusion, it now appears that surface and phonological dyslexia can both be observed in transparent and in opaque alphabetic orthographies. The underlying impairment in surface dyslexia seems to be the same even if it manifests itself somewhat differently in transparent and opaque alphabetic writing systems.

Letter position dyslexia

Both the identity and the position of letters in a word must be accurately encoded if the representation of a written word is to be activated in the orthographic system. It appears that there are some individuals who are aware of the identity but not necessarily the position of letters in a written word. This disorder is known as letter positional dyslexia (LPD) and it appears to present in both acquired [43]

and developmental forms [44]. There have now been published reports of developmental letter position dyslexia (LPD) in English [45-46], Arabic [47] and Hebrew [48]. A thorough review of the characteristics of LPD has recently been published [8], and this section provides a summary of its main contents.

The hallmark of LPD is for the letters in a word to 'migrate' during reading. An example of a migration error made by an individual with LPD would be reading *from* as *form*. It appears that this impairment is mainly affects the central letter positions, with the first and last letters being unaffected. Errors are therefore more likely on anagram words in which a letter-position error in the mid-region of a word can create a real word (*tried/tired, calm/clam, board/broad* etc.) If this form of dyslexia is to be identified by clinicians, it is crucial that reading tests contain a substantial numbers of words of this kind. Children with LPD make fewer migration errors when reading text than single words [44], presumably because syntactic and pragmatic constraints inform the reader that the migration error would not make sense in the context.

The likelihood of making errors in LPD appears to be affected by frequency. That is, it would be improbable for an individual with LPD to read a word of relatively high frequency such as *goal* as its lower frequency anagram *gaol;* reading *gaol* as *goal* would be much more likely to occur. One possible explanation is that a high frequency word requires less activation for it to be identified, and so it will be recognized even if an individual with LPD incorrectly encodes the location of one or more of its letters [8].

Individuals with LPD also show a tendency to omit letters that appear more than once in a word. This occurs when omission of the letter nonetheless produces a real word. So, for example, a word such as *drivers* contains two examples of the

letter *r*, and omission of the first *r* will produce the real English word *divers*. Nonwords may also be read incorrectly if transposition of their internal letters produces a real word. For example, a nonword such as *folp* might be read as *flop* in LPD. Because transposition errors affect both words and nonwords, LPD does not seem to be related to surface dyslexia.

There is, however, no evidence that individuals with LPD make migration errors when reading sequences of numbers [49]. There is also no evidence that individuals with LPD encounter any attentional problems. Moreover migration errors are not typically observed in those who do have attentional disorders [50]. These findings make it unlikely that LPD is the consequence of an attentional deficit or of a more basic visual processing problem.

Conclusion

Recent research findings confirm that there is indeed more than just one dyslexic reader. Individuals with surface dyslexia, phonological dyslexia, and letter position dyslexia appear to have suffered qualitatively different types of developmental reading impairment. These individual differences in dyslexia can be observed amongst readers of Hebrew, amongst readers of English and amongst readers of more transparent alphabetic orthographies such as Greek. Moreover subtypes of surface dyslexia have been observed in readers of English [29] as well as Hebrew [27-28]. These unusual patterns of reading are not readily observed amongst younger normal readers. There is no evidence that all of these dyslexic readers suffer from an underlying phonological deficit [10].

Conflict of Interest: Rick Hanley has nothing to disclose.

Compliance with ethical standards

All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

References

Papers of particular interest that were published 2012-2017 are highlighted as being:
• Of importance
•• Of major importance

1. Ellis AW. Reading, writing, and dyslexia: A cognitive analysis (classic edition): Routledge; 2016.

2. Snowling MJ, Hulme C. The nature and classification of reading disorders – a commentary on proposals for DSM-5. Jnl. Child Psychol Psychiat. 2012; 53:593–607.

3. **Peterson RL, Pennington, B.F. Developmental dyslexia. Annu Rev Clin Psychol. 2015;11:9.1–9.25. **This study contains a thorough discussion of phonological impairments in dyslexia.**
.
4. Snowling MJ. Specific disorders and broader phenotypes: The case of dyslexia. Quart Jnl Exp Psychol. 2008;61:142–56.

5. **Thompson PA, Hulme C, Nash HM, Gooch D, Hayiou-Thomas E, Snowling, MJ Developmental dyslexia: Predicting individual risk. Jnl Child Psychol Psychiat. 2015;56:976-87. **This study reports a longitudinal study of individuals at risk of dyslexia**.

6. Wilkins AJ, Allen PM, Monger LJ, Gilchrist JM. Visual stress & dyslexia for the practising optometrist. Optometry in Practice. 2016:17:103-12.

7. Oakhill J, Berenhaus MS, Cain K. Children's reading comprehension and comprehension difficulties. In Pollatsek A, Treiman R, editors. The Oxford handbook of reading: Oxford University Press; 2015

8. ** Friedmann N, Coltheart M. Types of developmental dyslexia. In Bar- On, A, Ravid D, editors. Handbook of communication disorders: Theoretical, empirical, and applied linguistics perspectives. De Gruyter Mouton: 2017. **Detailed account of many dyslexic subgroups**.

9. Snowling, MJ. Dyslexia. 2nd Edition: Blackwells; 2000.

10. Castles A, Friedmann N. Developmental dyslexia and the phonological deficit hypothesis. Mind Lang. 2014;29:270–85. **Critique of the view that dyslexia is always the result of a phonological impairment.**

11. Castles A, Coltheart M. Cognitive correlates of developmental surface dyslexia: A single case study. Cog Neuropsy. 1996;13:25-50.

12. Castles A, Bates T, Coltheart M. John Marshall and the developmental

dyslexias. Aphasiol. 2006;20:871-92.

13. **Peterson RL, Pennington BF, Olson RK. Subtypes of developmental dyslexia: Testing the predictions of the dual-route and connectionist frameworks. Cognition. 2013; 126:20-38. **This paper reports a large scale study of surface and phonological dyslexic subtypes.**

14. Peterson RL, Pennington BF, Olson RK, Wadsworth SJ. Longitudinal Stability of phonological and surface subtypes of developmental dyslexia. Scient Stud Read. 2014;18:347-62.

15. Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Zeigler, J. DRC: A dual route cascaded model of visual word recognition and reading aloud. Psychol Rev. 2001;108:204-56.

16. Perry C, Ziegler JC, Zorzi M. Beyond single syllables: Large-scale modelling of reading aloud with the Connectionist Dual Process (CDP++) model. Cognit Psychol. 2010;61:106-51.

17. Grainger, J. Ziegler, J.C. A dual-route approach to orthographic processing. Front Psychol. 2011;20:54.

18. *Woollams, A. Connectionist neuropsychology: Uncovering ultimate causes of acquired dyslexia. Philosophical Transactions of the Royal Society B. 2014;369:16-34. **This paper contains discussion of developmental dyslexia in terms of the triangle model of reading.**

19. Harm, MW, Seidenberg MS. Phonology, reading acquisition, and dyslexia: insights from connectionist models. Psychol Rev. 1999;106:491-528.

20. *McCarthur G, Kohnen S, Larson L, Jones K, Anandakumar T, Banales E, Castles A. Getting to grips with the heterogeneity of developmental dyslexia. Cog Neuropsy. 2014;30:1-24. **This paper contains a detailed summary of characteristics of surface and phonological subtypes.**

21. Manis FR., Seidenberg MS, Doi LM, McBride-Chang C, Petersen A. On the bases of two subtypes of development dyslexia. Cognition. 1996;58:157-95.

22. Stanovich KE, Siegel LS., Gottardo A. Converging evidence for phonological and surface subtypes of reading disability. Jnl Educ Psychol. 1997;89:114-27.

23. Jackson, N. E. & Coltheart, M. Routes to reading success and failure: Toward an integrated cognitive psychology of atypical reading: Psychology Press; 2001.

24. McDougall P, Borowsky R, MacKinnon GE, Hymel S. Process dissociation of sight vocabulary and phonetic decoding in reading: A new perspective on surface and phonological dyslexia. Brain Lang. 2005;92:185-203.

25. Douklias S, Masterson J, Hanley, JR. Surface and phonological developmental dyslexia in Greek. Cog Neuropsy. 2009**;**26:705-23.

26. Wybrow, DP, Hanley, JR. Surface developmental dyslexia is as prevalent as phonological dyslexia when appropriate control groups are employed. Cog Neuropsy. 2015**;**32:1-13.

27. Friedmann N, Lukov L. Developmental surface dyslexias. Cortex. 2008;44:1146-60.

28. **Gvion, A, Friedmann N. A principled relation between reading and naming in acquired and developmental anomia: Surface dyslexia following impairment in the phonological output lexicon. Front Psychol: Lang Sci. 2016;7:1-16. **This paper documents a form of surface dyslexia that is caused by a speech production problem.**

29. *Sotiropoulos A, Hanley JR. Lexical decision performance in developmental surface dysgraphia: Evidence for a unitary orthographic system that is used in both reading and spelling. Cog Neuropsy. In press. **This paper documents different types of surface dyslexia/dysgraphia in English.**

30. Rapp B, Lipka K. The literate brain: The relationship between spelling and reading. Jnl Cog. Neurosc. 2011;23:1180-97.

31. Goulandris NK, Snowling M. Visual memory deficits: A plausible cause of developmental dyslexia? Evidence from a single case study. Cog Neuropsy. 1991;8:127-54.

32. Plaut DC, McClelland JL, Seidenberg MS, Patterson K. Understanding normal and impaired word reading: Computational principles in quasi-regular domains. Psych Rev. 1996;103:56-115.

33. Di Betta AM, Romani C. Lexical learning and dysgraphia in a group of adults with developmental dyslexia. Cog Neuropsy. 2006;23:376–400.

34. Hulme C, Goetz K, Gooch D, Adams J, Snowling M. Paired-associate learning, phoneme awareness, and learning to read. Jnl Exptl Child Psychol. 2007;96:150–166

35. Wang H-C, Nickels, L, Castles A. Orthographic learning in developmental surface and phonological dyslexia. Cog Neuropsy. 2015; 32: 58-79

36. Ziegler JC, Castel C, Pech-Georgel C, George F, Alario FX, Perry, C. Developmental dyslexia and the dual route model Of reading: Simulating individual differences and subtypes. Cognition. 2008;107:151–178.

37. Paizi D, Zoccolotti P, Burani, C. Lexical stress assignment in Italian developmental dyslexia. Read Writ. 2011;24:443–461.

38. Dulay K.M, Hanley JR. Stress errors in a case of developmental surface dyslexia in Filipino. Cog Neuropsy. 2015;32:29-37.

39. Niolaki G, Terzopoulos A, Masterson J. Varieties of developmental dyslexia in Greek. Writing Systems Research. 2014;6:230-256

40. *Sotiropoulos A, Hanley JR. Surface and phonological developmental dyslexia in both Greek and English. Cognition. 2017;168:205-216. **This paper demonstrates parallels between dyslexic subgroups in Greek and English.**

41. Bergmann J, Wimmer H. A. dual-route perspective on poor reading in a regular orthography: Evidence from phonological and orthographic lexical decisions. Cog Neuropsy. 2008;25,653–676.

42. Ziegler JC, Goswami U. Reading acquisition, developmental dyslexia and skilled reading across languages: A psycholinguistic grain size theory. Psych Bull. 2005;131:3-29.

43. Friedmann N, Gvion A. (2001). Letter position dyslexia. Cog Neuropsy. 2001; 18:673–696.

44. Friedmann, N, Rahamim E. Developmental letter position dyslexia. Jnl.of Neuropsych. 2007;1:201–236. □

45. Kezilas Y, Kohnen S, McKague M, Castles A. The locus of impairment in English developmental letter position dyslexia. Front Hum Neurosc. 2014;8:1-14.

46. **Kohnen S, Nickels L, Castles A, Friedmann N, McArthur G. When 'slime' becomes 'smile': Developmental letter position dyslexia in English. Neuropsychologia, 2012;50:3681–92. **This paper describes letter position dyslexia in English.**

47. Friedmann N, Haddad-Hanna M. Letter position dyslexia in Arabic: From form to position. Behav Neurol. 2012;25:193–203. □

48. Friedmann N, Gvion, A, Nisim R. Insights from developmental and acquired letter position dyslexia on morphological decomposition in reading. Front Hum Neurosc. 2015;9:143.

49. Friedmann N, Dotan D, Rahamim E. Is the visual analyzer orthographic-specific? Reading words and numbers in letter position dyslexia. Cortex, 2010;46:982–1004.

50. Lukov, L., Friedmann, N., Shalev, L., Khentov-Kraus, L., Shalev, N., Lorber, R., & Guggenheim, R. Dissociations between developmental dyslexias and attention deficits. Front Psychol. 2015;5:1-18. □