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A Review of Prosody, Punctuation, and Dyslexia: Implications for the Use of Speech Technologies

Chara Triantafyllidou[1]

1 University of Cambridge

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Abstract

Multiple studies and observations have shown that dyslexic students tend to omit punctuation from their writing, but the roots of this difficulty remain largely unexplored. However, there is a significant body of research on prosodic processing in dyslexia, which is relevant to punctuation as a form of written prosody. The aim of this review paper is to outline the relationship between oral prosody, written prosody, and dyslexia by discussing recent neurocognitive findings on prosodic processing and dyslexia. On the basis of the relevant literature regarding prosodic awareness and auditory processing, it describes the implications of these findings for prosodic training in dyslexia and the use of speech technologies. This includes practical implications for the use of Computer-Assisted Language Learning (CALL) tools in language teaching. Finally, the paper concludes by summarising potential research questions for future research on dyslexia on the basis of the gaps identified in the previously cited literature.

Prosody, Punctuation, and Dyslexia: The Affordances of Speech Technologies in the Classroom

Dyslexia is a specific learning disability characterised by reading difficulties, especially in accurate and fluent word recognition, poor decoding and spelling abilities (International Dyslexia Association, 2002). It is well established that phonological awareness, i.e. the awareness of the sound structure of words, is compromised in dyslexia, especially on the phoneme level, i.e. the individual sound unit distinguishing words. According to the Phonological Deficit Hypothesis, phonological processing is impaired in dyslexia, a deficit which impacts reading and writing skills (Rack, 2018; Snowling, 1998). However, it has been exemplified that dyslexic children have several cognitive deficits, for instance in visual and auditory processing, as well as in working memory, and it has been hypothesised that these cognitive deficits are the root cause of dyslexia, rather than the issues in phonological process (Wright et al., 2000).

This paper focuses specifically on prosody, which describes the elements of speech beyond the phoneme level, such as intonation, stress, rhythm, and pauses (Kuhn et al., 2010, pp. 233-234), and which are relevant to auditory processing and speaking skills. Prosody can be subcategorised into explicit and implicit prosody. Implicit prosody describes the prosodic contours of our inner voice during silent reading, as opposed to the explicit prosody produced in speech (Breen, 2014;

Drury et al., 2016). Specifically, according to Fodor's (2002) Implicit Prosody Hypothesis, the prosodic structures generated during silent reading match the prosodic structures produced when reading aloud. Therefore, implicit prosody is language dependent and reflects the accent spoken by the reader (Filik & Barber, 2011; Jun, 2010). This has implications for the development of reading, which might not rely exclusively on decoding, but also on prosody (Godde et al., 2020; Groen et al., 2019).

Prosody is manifested in writing through punctuation. Punctuation is a form of explicit written prosody: it acts as a visual trigger facilitating text chunking and syntactic processing in reading (Schmidt et al., 2019; Steinhauer, 2003), and it indicates structural relations in the discourse (Dale, 1991). Punctuation is especially relevant to dyslexia, due to the widely documented difficulties of dyslexic students with the use of punctuation in writing (Feka, 2016; Sumner & Connelly, 2020; Tops et al., 2013). This paper considers all aspects of prosody, with a focus on explicit prosodic processing, which is relevant to the use of speech technologies, considering that Text-to-Speech (TTS) is particularly popular in dyslexia-specific software. For a review of such software and the use of technology with dyslexic students, see also Indal & Maveus (2019), Ili Farhana (2018), Satapathy (2019), and Triantafyllidou (2020, pp. 41-61).

Elements of Prosody

Most studies agree that there are specific elements of prosody that are relevant to the process of chunking speech into parsable units: pitch, stress, duration, and pausing all contribute to the chunking process. For instance, Kuhn et al. (2010, p. 235) explain that word-final lengthening, declination, and pausing usually signify the end of a unit. Apart from pitch, the encoding of amplitude modulations appears to be important for speech intelligibility, as Goswami (2019a, p. 6) argues, which implies that amplitude might also play a key role in the processing of prosody.

Similarly, Heggie and Wade-Woolley (2018) point out the importance of pitch and pause and state that intonation affects the semantic perception of information as emphasis is placed on certain constituents (p. 190); this also shows an example of interfaces between prosody and syntax, which are also discussed below. Moreover, they explain the importance of commas, which "appear to facilitate processing whenever they appear in conjunction with a clause boundary, whether or not they are required for disambiguation" (2018, p. 192), which shows that pauses influence speech intelligibility. Finally, they clarify that syntactic boundaries can sometimes occur without prosodic boundaries and this is precisely the aspect of interfaces between prosody and syntax that has not been deciphered yet and perhaps one that influences the perception and use of punctuation.

Punctuation and Prosody

There is widely discussed parallel between prosody and punctuation, as both contribute to the process of syntactic disambiguation, i.e. the process of resolving unclear structures, such as garden-path sentences (Heggie & Wade-Woolley,

2018, p. 191). Similarly, prosody breaks up continuous speech for parsing (Kuhn et al., 2010, p. 235). Prosody chunks speech into units that allow disambiguation, creating “a cognitive skeleton that allows one to hold an auditory sequence in working memory” (Kuhn et al., 2010, p. 235). Even though syntax and prosody interact, drawing correlation between the two is not a straightforward process, due to the “schizophrenic” relationship between written prosody (i.e. punctuation) and oral prosody (Baron, 2001, pp. 62-63). Heggie and Wade-Woolley (2018), Veenendaal et al. (2014), and Wolff (2002), acknowledge that oral prosody is realised in writing through punctuation, but also explain that this unclear relationship results in students having to learn how to use punctuation through instruction and not being able to acquire it.
Moreover, there are several examples of punctuation being “invisible” in speech. This is especially the case with apostrophes, which in English can change the meaning of a pronoun, as seen below:

(a)	It’s	a	good	day.
	* Its	a	good	day.
(b)	He’s	being	weird	today.
	*His	being	weird	today.

There are no speech elements that can indicate the difference between the two structures, one of which results in ungrammatical sentences in each example. This also renders implicit forms of corrective feedback inefficient, e.g. repetitions or recasts, which could be automatically provided through a TTS and combined with text enhancement to draw attention to errors (Rassaei, 2020).

Apart from the inconsistencies between prosody and punctuation, there is significant inconsistency between language users’ preferences regarding the use of punctuation. This is an issue identified in Natural Language Processing, because the individual differences in the use of punctuation prevents parsers from generalising as Søgaard et al. (2018) explain. There are several examples of ungrammatical punctuation use for emphasis and lack of punctuation in informal texts, which leads to more efficient neural parser training when punctuation is completely absent from a text.

In a small-scale study (n=10) presented in Triantafyllidou (2020), I demonstrate the variation in the use of punctuation by adult expert native-speakers of English who are trained to teach English in Irish post-primary education. Issues arose especially with commas, such as Oxford commas and non-restrictive relative clauses. Another issue was the preferred type of pause (i.e.: commas, semi-colons, colons, full-stops), which often led to lengthier periods. Compared to the original texts, which were selected from secondary education textbooks, there was notable deviation both in the variety of punctuation marks used and the number of punctuation marks within each response. For a detailed analysis of the data extracted from this study, see Triantafyllidou (2020, pp. 15-29).

Considering that punctuation significantly affects the clarity and coherence of a text, little attention has been paid to ways of improving punctuation in the writing of dyslexic students. Some studies examine punctuation errors in dyslexic adults, as seen for instance in Mortimore and Crozier (2006). Interestingly enough, however, the researchers group grammar and punctuation errors and do not examine punctuation on its own (2006, pp. 245-246). More recent studies examine the use of punctuation by dyslexic students in languages other than English (Feka, 2016; Protopapas et al., 2013; Tops et al.,

2013), finding mixed results, which seem to be dependent on the language. While the impact of deep orthographies on punctuation are beyond the scope of this study, it is notable that English is a language characterised by a fluid punctuation system. Stemming from this, dyslexic students of English would have to encounter not only the reading difficulties that render proof-reading ineffective, but also an inconsistent punctuation system, which seems to be dependent on semantics and not only syntax (Heggie & Wade-Woolley, 2018). Moreover, in studies analysing errors in dyslexic writing, punctuation errors are often ignored. For instance, Rello et al. (2012, 2014) have compiled a corpus of dyslexic writing, but they only classify word-level and phrase-level errors. In corpus research it would be useful, especially for teachers, to consider punctuation errors since they affect the coherence and cohesion of a text.

While the use of punctuation remains largely undocumented in dyslexic students, especially in primary and secondary education, there has been a significant body of research dedicated to prosodic processing in dyslexia, presented below. Gaps in the relevant literature are identified throughout this paper and summarised in the conclusive remarks towards the end.

Prosodic Processing in Dyslexia

Overall, recent findings suggest that linguistic prosodic sensitivity is impaired in dyslexia and show that prosody and punctuation might interact both in reading and writing performance. This section provides an overview of such findings spanning over the last decade.

Extended research on prosodic processing and dyslexia has been conducted by Usha Goswami. Goswami et al. (2010) outline the research that has been done regarding phonological awareness, especially in terms of the “perception of the speech envelope and of the slower amplitude-driven modulations that are important for speech intelligibility” (p. 996). They place particular emphasis on rise time, which is correlated with the onset of stressed syllables, and whose impairment affects prosodic processing. This study also cites works discussing the importance of prosodic sensitivity for reading comprehension, and brings attention to the lack of research on the links between prosodic sensitivity, phonological awareness, and decoding (2010, p. 998). The findings of the study include impairments in phrase-level prosodic cues (2010, p. 1015), which is relevant to punctuation and the segmentation of sentences into prosodically distinct phrases. In a later study, Goswami et al. (2016) focused on word-level prosody and showed short-term memory effects, with dyslexic participants having difficulties at retention of prosodic structures.

The impairment of prosodic processing in dyslexia is especially relevant to the interfaces between prosody and syntax. First of all, Sabisch et al. (2006) demonstrate that prosodic information is accessed during auditory comprehension, but their ERPs study shows that dyslexic children do not rely on that prosodic information to decode meaning. The ERPs show lack of activation in areas in charge of prosodic processing, which are further discussed below, thus indicating deficits in prosodic processing. Agreeing with these findings, Honbolygó et al. (2016) also showed the importance of

prosody for the construction on meaning and the interfaces between prosody and syntax. Similarly, Marshall et al. (2009) report impairments where syntax interacts with prosody, for instance in chunking (p. 480), but observe no or little evidence of prosodic impairments in the cases where prosody does not interact with linguistic meaning. Similarly, Caccia & Lorusso (2019) observe no significant impairments in non-linguistic prosody. However, Calet et al. (2019) present contrasting evidence and their findings indicate that dyslexic children exhibit an overall deficit in prosody. Finally, implicit prosody in silent reading remains unexplored in dyslexic students, as most prosodic tasks in these studies focus on explicit prosodic reception and production.

Finally, one recent study focuses specifically on the interfaces between prosody and punctuation. Heggie and Wade-Wolley (2018) present evidence that prosodic awareness is a strong predictor of punctuation ability in adults and that punctuation and prosody facilitate reading comprehension. Specifically, they studied receptive and productive prosodic awareness and productive punctuation ability in literate, educated adults and found statistically significant correlations between prosodic awareness and punctuation skills. However, this relationship has not been explored in dyslexic students or dyslexic learners of English as a foreign language.

Prosodic Training in Dyslexia

Stemming from the above, one may argue that since explicit linguistic prosodic processing is impaired in dyslexia, using TTS technologies for punctuation correction is counter-intuitive. There is, however, some evidence that auditory and prosodic training can be used to improve neural processing in dyslexia, as well as short-term auditory memory and punctuation. Goswami (2011, 2019a, 2019b) offers a neural oscillations perspective towards prosodic processing and proposes that auditory training can improve neural processing in dyslexia. In Goswami (2019a), she reports slower neural processing and atypical oscillatory function in dyslexic people at bands relevant to prosodic processing and speech intelligibility, i.e. the theta and delta bands. As explained in Goswami (2011, 2019b) and Thomson et al. (2013), there is potential in using a remediation programme based on rhythm and music in the form of syllable patterns in order to improve prosodic processing. The remediation programme suggested focuses on children prior to instruction age and appears to be relevant mostly to explicit segmental prosody. In an older project, Goswami adapted a Finnish game, *GraphoGame Rime*, to its English version. *GraphoGame Rime* is a phonics game using rhyme and musical interventions to train dyslexic students and was found to be efficient in primary school interventions regarding the improvement of reading and spelling skills (Ahmed et al., 2020).

Regarding short-term auditory memory, Zygouris et al. (2018) present a remediation programme with various activities for nine-to-eleven-year-old Greek dyslexic students. Their programme included tasks where students had to memorise words and sentences they heard for auditory training. The effect of this programme was measured through a clinical neuropsychological battery of tests and ERPs and was found to be significantly effective for auditory short-term memory with substantial effect sizes. Moreover, the pre-remediation ERPs showed increased latency in the P300 waveform for dyslexic students dealing with auditory stimuli, while these high frequencies were not observed post-remediation. The

programme of Zygouris et al. (2018) shows that incorporating explicit prosody training in dyslexia remediation can be effective and that this improvement can be measured neurocognitively.

Finally, Calet et al. (2017) present a fluency training programme for non-dyslexic students primary school students, using prosody training for expressive reading and punctuation. Their pre- and post-test measures included tasks where students had to read aloud punctuated text giving the proper expression according to the punctuation, as well as tasks where students had to insert punctuation in written text. Additionally, prosodic reading was measured using a scale measuring skills in volume, intonation, pauses, and phrasing. The training programme included both implicit and explicit prosody, with silent reading and reading aloud repeated tasks, as well as oral and spelling activities focusing on stress sensitivity, intonation sensitivity, and punctuation. A statistically significant effect was detected in the improvement of prosodic reading, punctuation, as well as in sentence comprehension. While this study is not focusing on dyslexia, it shows the impact of prosody training on punctuation skills and the potential of such training.

Dyslexia and Speech Technologies

Impaired prosodic processing in dyslexia has implications for the use of speech technologies for language learning. As mentioned above, TTS applications are particularly popular in dyslexia-specific software. TTS assists students in reading and, potentially, in proof-reading their own typed texts. However, if students struggle at picking up on the prosody of words and phrases, this does not only mean that proof-listening could be ineffective; it also means that dyslexic students might not be able to rely on TTS for reading purposes.

Speech synthesis has not yet reached the desired level of naturalness and this is reflected in synthetic speech intelligibility. Giannouli and Banou (2019) researched the intelligibility of synthetic speech in primary and post-primary dyslexic students in Greece and found that words and sentences were statistically significantly easier to parse in natural speech. However, whole texts were intelligible due to contextual clues and the difficulties encountered with words and sentences were absent in the text comprehension condition. One issue in this study is that, while the TTS system the researchers used was advanced enough to replicate prosody to a high degree, they did not implement the use of TTS in the classroom, which has showed to improve ratings of intelligibility for speech synthesisers (Ní Chiaráin & Ní Chasaide, 2017).

However, implementing speech technologies in the classroom also bears its own difficulties. One factor to take into account is classroom management and the possibility of using speech technologies in group-work and pair-work. Most tools are designed to assist in individual study and text proofreading, while game applications do not provide an environment for co-operative play (Triantafyllidou, 2020, pp. 41-61). Regarding teachers' perspectives on the use of technologies with dyslexic students, there are overall favourable views, as seen in Blackburn (2018) and Granzen (2018). Blamire & Omidire (2020) report that mobile technology is also viewed favourably for inclusive education. The authors

point out that the implementation process still presents challenges, such as technical difficulties, while there is a need for continuous professional development merging inclusive education and technological training.

Implications for Teaching

The findings and observations analysed in this paper bring forward the following implications regarding the use of speech technologies in language teaching:

1. Text-to-Speech use: Based on the studies of Gosawmi (2011, 2019a, 2019b) and Zygouris (2018), using TTS to proof-listen to text might be beneficial in improving prosodic sensitivity in the long run. However, there are no conclusive findings suggesting that there are benefits for the students.
2. Evaluation of tools: It is important that tools and software are evaluated both prior to their implementation, as well as throughout the implementation process, in order to ensure that they promote learner autonomy and support the students' cognitive, educational, and emotional needs. Computer-Assisted Language Learning (CALL) frameworks provide such guidance for teachers and researchers.
3. Individual differences: It is important to consider that, even among dyslexic students, there are individual differences in preferences; see for instance font preferences in Rello & Baeza-Yates (2016). Therefore, differentiated instruction requires adaptability and continuous assessment of technological tools to assess whether they serve their purpose and address students' needs.

Regarding CALL evaluation in particular, there are several frameworks available, such as the TATL Framework (Ní Chiaráin & Ní Chasaide, 2015) and Rosell-Aguilar's (2017) "State of the App" taxonomy. An issue detected with some evaluation frameworks is that they are mostly suitable for researchers rather than educators due to their length and detail-oriented approach, as seen for instance in the TPACK framework (Koehler et al., 2014) or the framework of McMurry et al. (2016). In Triantafyllidou (2020, pp. 42-43), I present an evaluation blueprint summarised in a table, which aims at providing an accessible evaluation tool for language practitioners.

Limitations and Future Research

Limitations in this field of research include:

1. The lack of cross-linguistic research on the neurology of dyslexia (Hadzibeganovic et al., 2010): It is possible that testing prosody and punctuation in non-English speaking individuals would not yield the same results as those of Heggie and Wade-Woolley (2018).
2. Non-conclusive findings regarding prosodic impairments in dyslexia: There are some studies that argue in favour of prosody being intact, such as Geiser et al. (2014) and Männel et al. (2017). Age might also be a factor weighing in the impairment of prosody, an aspect that has also not been longitudinally researched.

Finally, future research should address the following aspects:

1. Implicit prosody and silent reading in dyslexia
2. Correlations between punctuation and prosody in deep orthographies
3. Individual differences in punctuation and punctuation skills in dyslexia
4. Prosodic training and proof-listening in dyslexia, as well as punctuation training in dyslexia
5. Speech technologies with dyslexic students in the interactive environment of the classroom.

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Correspondence concerning this article should be addressed to Charikleia Triantafyllidou; e-mail:triantac@tcd.ie

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References

Ahmed, H., Wilson, A., Mead, N., Noble, H., Richardson, U., Wolpert, M. A., & Goswami, U. (2020). An Evaluation of the Efficacy of GraphoGame Rime for Promoting English Phonics Knowledge in Poor Readers. *Frontiers in Education*, *5*, 132. https://doi.org/10.3389/feduc.2020.00132

Baron, N. S. (2001). Commas and canaries: The role of punctuation in speech and writing.*Language Sciences*, *23*(1), 15–67. https://doi.org/10.1016/S0388-0001(00)00027-9

Blackburn, M. F., & Vittrup, B. (2018). Teachers' perceptions on the use of technology in the classroom to teach students identified with dyslexia. In *Dissertation Abstracts International Section A: Humanities and Social Sciences* https://twu-ir.tdl.org/handle/11274/10143

Blamire, M., & Omidire, M. F. (2020). Teachers' Perspectives on Mobile Technology as an Inclusive Strategy for Students with Dyslexia. *E-Bangi*, *17*(3), 1823–1884. https://ejournal.ukm.my/ebangi/article/view/39975

Breen, M. (2014). Empirical Investigations of the Role of Implicit Prosody in Sentence Processing.*Language and Linguistics Compass*, *8*(2), 37–50. https://doi.org/10.1111/lnc3.12061

Caccia, M., & Lorusso, M. L. (2019). When prosody meets syntax: The processing of the syntax-prosody interface in children with developmental dyslexia and developmental language disorder. *Lingua*, *224*, 16–33. https://doi.org/10.1016/j.lingua.2019.03.008

Calet, N., Gutiérrez-Palma, N., & Defior, S. (2017). Effects of fluency training on reading competence in primary school children: The role of prosody. *Learning and Instruction*, *52*, 59–68. https://doi.org/10.1016/j.learninstruc.2017.04.006

Calet, N., Gutiérrez-Palma, N., Defior, S., & Jiménez-Fernández, G. (2019). Linguistic and non-linguistic prosodic skills in Spanish children with developmental dyslexia. *Research in Developmental Disabilities*, *90*, 92–100. https://doi.org/10.1016/j.ridd.2019.04.013

Dale, R. (1991). The role of punctuation in discourse structure. *Proceedings of a Workshop on Text Representation and Domain Modelling: Ideas from Linguistics and AI*, 110–120. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.15.1830&rep=rep1&type=pdf

Drury, J. E., Baum, S. R., Valeriote, H., & Steinhauer, K. (2016). Punctuation and implicit prosody in silent reading: An ERP study investigating english garden-path sentences. *Frontiers in Psychology*, *7*(SEP), 1375. https://doi.org/10.3389/fpsyg.2016.01375

Feka, M. (2016). *Dyslexia in Greek as an L1 and in English as an L2: A Case Study* (Publication No. GRI-2017-18854) [Master's dissertation: Aristotle University of Thessaloniki]. IKEE Repository. http://ikee.lib.auth.gr/record/288302?ln=el

Filik, R., & Barber, E. (2011). Inner speech during silent reading reflects the reader's regional accent. *PLoS ONE*, *6*(10), e25782. https://doi.org/10.1371/journal.pone.0025782

Fodor, J. D. (2002). Prosodic disambiguation in silent reading. *North East Linguistics Society*, 32(1), 112–132.

Geiser, E., Kjelgaard, M., Christodoulou, J. A., Cyr, A., & Gabrieli, J. D. E. (2014). Auditory temporal structure processing in dyslexia: Processing of prosodic phrase boundaries is not impaired in children with dyslexia. *Annals of Dyslexia*, *64*(1), 77–90. https://doi.org/10.1007/s11881-013-0087-7

Giannouli, V., & Banou, M. (2019). The intelligibility and comprehension of synthetic versus natural speech in dyslexic students. *Disability and Rehabilitation: Assistive Technology*, 1–10. https://doi.org/10.1080/17483107.2019.1629111

Godde, E., Bosse, M. L., & Bailly, G. (2020). A review of reading prosody acquisition and development. *Reading and Writing*, *33*(2), 399–426. https://doi.org/10.1007/s11145-019-09968-1

Goswami, U. (2011). A temporal sampling framework for developmental dyslexia. In *Trends in Cognitive Sciences* (Vol. 15, Issue 1, pp. 3–10). Elsevier Current Trends. https://doi.org/10.1016/j.tics.2010.10.001

Goswami, U. (2019a). A neural oscillations perspective on phonological development and phonological processing in developmental dyslexia. *Language and Linguistics Compass*, *13*(5), e12328. https://doi.org/10.1111/lnc3.12328

Goswami, U. (2019b). Speech rhythm and language acquisition: an amplitude modulation phase hierarchy perspective. In *Annals of the New York Academy of Sciences* (Vol. 1453, Issue 1, pp. 67–78). Blackwell Publishing Inc. https://doi.org/10.1111/nyas.14137

Goswami, U., Barnes, L., Mead, N., Power, A. J., & Leong, V. (2016). Prosodic Similarity Effects in Short-Term Memory in Developmental Dyslexia. *Dyslexia*, *22*(4), 287–304. https://doi.org/10.1002/dys.1535

Goswami, U., Gerson, D., & Astruc, L. (2010). Amplitude envelope perception, phonology and prosodic sensitivity in children with developmental dyslexia. *Reading and Writing*, *23*, 995–1019. https://doi.org/10.1007/s11145-009-9186-6

Granzen, T. (2018). How High School Students With Dyslexia Use Assistive Technology; A Teacher's Perspective. In *CUP Ed.D. Dissertations*. https://digitalcommons.csp.edu/cup_commons_grad_edd/182

Groen, M. A., Veenendaal, N. J., & Verhoeven, L. (2019). The role of prosody in reading comprehension: evidence from poor comprehenders. *Journal of Research in Reading*, 42(1), 37–57. https://doi.org/10.1111/1467-9817.12133

Hämäläinen, J. A., Salminen, H. K., & Leppänen, P. H. T. (2013). Basic Auditory Processing Deficits in Dyslexia: Systematic Review of the Behavioral and Event-Related Potential/ Field Evidence. *Journal of Learning Disabilities*, *46*(5), 413–427. https://doi.org/10.1177/0022219411436213

Heggie, L., & Wade-Woolley, L. (2018). Prosodic awareness and punctuation ability in adult readers. *Reading Psychology*, *39*(2), 188–215. https://doi.org/10.1080/02702711.2017.1413021

Honbolygó, F., Török, Á., Bánréti, Z., Hunyadi, L., & Csépe, V. (2016). ERP correlates of prosody and syntax interaction in case of embedded sentences. *Journal of Neurolinguistics*, *37*, 22–33. https://doi.org/10.1016/j.jneuroling.2015.08.001

Ili Farhana, B. M. M. (2018). *Digital Text Presentation and Navigation to Support People with Dyslexia* (Publication No. uk.bl.ethos.787384) [Doctoral dissertation: University of York]. White Rose eTheses Online. http://etheses.whiterose.ac.uk/id/eprint/24697

Indal, E., & Mavéus, E. (2019). *Exploring the Web Accessibility for People with Dyslexia* [Bachelor dissertation: Malmö

University]. Malmö University Electronic Publishing. http://muep.mau.se/handle/2043/29188

International Dyslexia Association. (2002). *Definition of Dyslexia*. https://dyslexiaida.org/definition-of-dyslexia/

Jun, S. A. (2010). The implicit prosody hypothesis and overt prosody in English.*Language and Cognitive Processes*, *25*(7), 1201–1233. https://doi.org/10.1080/01690965.2010.503658

Koehler, M. J., Mishra, P., Kereluik, K., Shin, T. S., & Graham, C. R. (2014). The technological pedagogical content knowledge framework. In *Handbook of Research on Educational Communications and Technology: Fourth Edition*(pp. 101–111). Springer New York. https://doi.org/10.1007/978-1-4614-3185-5_9

Kuhn, M. R., Schwanenflugel, P. J., Meisinger, E. B., Levy, B. A., & Rasinski, T. V. (2010). Aligning Theory and Assessment of Reading Fluency: Automaticity, Prosody, and Definitions of Fluency. *Reading Research Quarterly*, *45*(2), 230–251. https://doi.org/10.1598/rrq.45.2.4

Männel, C., Schaadt, G., Illner, F. K., van der Meer, E., & Friederici, A. D. (2017). Phonological abilities in literacy-impaired children: Brain potentials reveal deficient phoneme discrimination, but intact prosodic processing. *Developmental Cognitive Neuroscience*, *23*, 14–25. https://doi.org/10.1016/j.dcn.2016.11.007

Marshall, C. R., Harcourtbrown, S., Ramus, F., & Van Der Lely, H. K. J. (2009). The link between prosody and language skills in children with specific language impairment SLI andor dyslexia. *International Journal of Language and Communication Disorders*, *44*(4), 466–488. https://doi.org/10.1080/13682820802591643

McMurry, B., Williams, D. D., & Rich, P. (2016). An Evaluation Framework for CALL.*TESL-EJ*, *20*(2), 1–31. https://eric.ed.gov/?id=EJ1113897

Miller, L. A., Collins, R. L., & Kent, T. A. (2008). Language and the modulation of impulsive aggression. In*Journal of Neuropsychiatry and Clinical Neurosciences* (Vol. 20, Issue 3, pp. 261–273). American Psychiatric Publishing Inc. https://doi.org/10.1176/jnp.2008.20.3.261

Mortimore, T., & Crozier, W. R. (2006). Dyslexia and difficulties with study skills in higher education. Studies in Higher Education, 31(2), 235–251. https://doi.org/10.1080/03075070600572173

Ní Chiaráin, N., & Ní Chasaide, A. (2015). The TATL framework for CALL development. In F. Helm, L. Bradley, M. Guarda, & S. Thouësny (Eds.), *Critical CALL: Proceedings of the 2015 EuroCALL Conference*(pp. 427–432). Research-publishing.net. https://doi.org/10.14705/rpnet.2015.000370

Ní Chiaráin, N., & Ní Chasaide, A. (2017). Effects of Educational Context on Learners' Ratings of a Synthetic Voice.*7th ISCA Workshop on Speech and Language Technology in Education*, 47–52. https://doi.org/10.21437/slate.2017-9

Protopapas, A., Fakou, A., Drakopoulou, S., Skaloumbakas, C., & Mouzaki, A. (2013). What do spelling errors tell us? Classification and analysis of errors made by Greek schoolchildren with and without dyslexia. *Reading and Writing*, *26*, 615–646. https://doi.org/10.1007/s11145-012-9378-3

Rack, J. P. (2018). Dyslexia: The Phonological Deficit Hypothesis. In A. Fawcett & R. Nicolson (Eds.),*Dyslexia in Children* (pp. 5–37). Routledge. https://doi.org/10.4324/9781315504773-2

Rassaei, E. (2020). The separate and combined effects of recasts and textual enhancement as two focus on form techniques on L2 development. *System*, *89*, 102193. https://doi.org/10.1016/j.system.2019.102193

Rello, L., & Baeza-Yates, R. (2016). The Effect of Font Type on Screen Readability by People with Dyslexia.*ACM Transactions on Accessible Computing*, *8*(4), 1–33. https://doi.org/10.1145/2897736

Rello, L., Baeza-Yates, R., & Llisterri, J. (2014). DysList: An annotated resource of dyslexic errors.*Proceedings of the 9th International Conference on Language Resources and Evaluation, LREC 2014*, 1289–1296. http://www.lrec-conf.org/proceedings/lrec2014/pdf/612_Paper.pdf

Rello, L., Baeza-Yates, R., Saggion, H., & Pedler, J. (2012). A first approach to the creation of a Spanish corpus of dyslexic texts. *LREC Workshop Natural Language Processing for Improving Textual Accessibility (NLP4ITA), Istanbul, Turkey*. https://pdfs.semanticscholar.org/f73e/085bf5a73a372fad89eccbdd2d1dc11c0247.pdf

Rosell-Aguilar, F. (2017). State of the App: A Taxonomy and Framework for Evaluating Language Learning Mobile Applications. *CALICO Journal*, *34*(2), 243–258. https://doi.org/10.1558/cj.27623

Sabisch, B., Hahne, A., Glass, E., Von Suchodoletz, W., & Friederici, A. D. (2006). Auditory language comprehension in children with developmental dyslexia: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience*, *18*(10), 1676–1695. https://doi.org/10.1162/jocn.2006.18.10.1676

Satapathy, A. (2019). Applications of Assistive Tools and Technologies in Enhancing the Learning Abilities of Dyslexic Children. *TechnoLearn An International Journal of Educational Technology*, *9*(2), 117–123. https://doi.org/10.30954/2231-4105.02.2019.9

Schmidt, E., Pérez, A., Cilibrasi, L., & Tsimpli, I. (2019). Prosody facilitates memory recall in L1 but not in L2 in highly proficient listeners. *Studies in Second Language Acquisition*, *42*(1), 223–238.

https://doi.org/10.1017/S0272263119000433

Snowling, M. (1998). Dyslexia as a Phonological Deficit: Evidence and Implications. *Child Psychology and Psychiatry Review*, *3*(1), 4–11. https://doi.org/10.1017/S1360641797001366

Søgaard, A., de Lhoneux, M., & Augenstein, I. (2018). Nightmare at test time: How punctuation prevents parsers from generalizing. *Proceedings of the 2018 EMNLP Workshop BlackboxNLP: Analyzing and Interpreting Neural Networks for NLP*, 25–29. https://doi.org/10.18653/v1/w18-5404

Steinhauer, K. (2003). Electrophysiological correlates of prosody and punctuation. *Brain and Language*, *86*(1), 142–164. https://doi.org/10.1016/S0093-934X(02)00542-4

Sumner, E., & Connelly, V. (2020). Writing and Revision Strategies of Students With and Without Dyslexia. Journal of Learning Disabilities, 53(3), 189–198. https://doi.org/10.1177/0022219419899090

Tops, W., Callens, C., van Cauwenberghe, E., Adriaens, J., & Brysbaert, M. (2013). Beyond spelling: The writing skills of students with dyslexia in higher education. *Reading and Writing*, *26*(5), 705–720. https://doi.org/10.1007/s11145-012-9387-2

Triantafyllidou, C. (2020). *Assistive Technologies for Dyslexia: Punctuation and its Interfaces with Speech*[Master's dissertation: Trinity College Dublin]. Trinity's Access to Research Archive (TARA) http://www.tara.tcd.ie/handle/2262/94118

Veenendaal, N. J., Groen, M. A., & Verhoeven, L. (2014). The role of speech prosody and text reading prosody in children's reading comprehension. *British Journal of Educational Psychology*, *84*(4), 521–536. https://doi.org/10.1111/bjep.12036

Wolff, P. H. (2002). Timing precision and rhythm in developmental dyslexia. *Reading and Writing*, *15*, 179–206. https://doi.org/10.1023/a:1013880723925

Wright, B. A., Bowen, R. W., & Zecker, S. G. (2000). Nonlinguistic perceptual deficits associated with reading and language disorders. In *Current Opinion in Neurobiology* (Vol. 10, Issue 4, pp. 482–486). Current Biology Ltd. https://doi.org/10.1016/S0959-4388(00)00119-7

Zygouris, N. C., Avramidis, E., Karapetsas, A. V., & Stamoulis, G. I. (2018). Differences in dyslexic students before and after a remediation program: A clinical neuropsychological and event related potential study. *Applied Neuropsychology: Child*, *7*(3), 235–244. https://doi.org/10.1080/21622965.2017.1297710