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Report on design of new teaching methods and remediation tools for dyslexia[1]

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University of Verona

Maria Vender, Chiara Melloni & Denis Delfitto

University of Reading

Diego Krivochen & Douglas Saddy

Morphological treatment as a valuable tool for the rehabilitation of dyslexia in bilingual and monolingual children

Abstract

The aim of this work is to provide a review of the remediation therapies that can be used in the rehabilitation of developmental dyslexia; a special emphasis is put on morphological instruction as a promising strategy for compensating the phonological deficits exhibited by dyslexic children, both monolinguals and bilinguals, and enhancing their literacy skills. We will begin our discussion by presenting an overview of developmental dyslexia, discussing its manifestations and its relationships with other developmental disorders, and in particular with Specific Language Impairment. We will then present the results of the studies that we carried out within the European Project AThEME, which confirm the presence of a morphological deficit in dyslexic children, but also point to an advantage in morphological tasks of bilingual children, both dyslexics and typically developing, over their monolingual peers. On the basis of these results, we propose that morphological training could be a viable and effective strategy for the treatment of reading difficulties in both monolingual and bilingual children. We will back this proposal up by presenting the results of three meta-analyses, for a total of 46 studies reviewed, confirming that morphological treatment can lead to enhancements in reading, spelling and literacy-related skills, including phonological and morphological competence, vocabulary development and reading comprehension.

1. An introduction to Developmental Dyslexia

Developmental Dyslexia is a neurodevelopmental genetic disorder characterized by a difficulty in acquiring properly reading and spelling skills, despite adequate classroom exposure, in absence of cognitive, physical or sensorimotor impairments and socio-economical or emotional problems (Vellutino 1979). It affects 3-10% of the population at large and it is highly inheritable (Snowling 2000). An extensive body of research has shown that dyslexia is characterized primarily by phonological difficulties, which represent the core deficit of this disorder (Snowling 1995; Ramus and Szenkovits 2008; Desroches et al. 2006). More recently, it has been demonstrated that the difficulties experienced by dyslexic children go beyond the domain of phonology,

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extending to other domains of linguistic competence, such as lexical development (Scarbourough 1990; Lyytinen et al. 2001; Snowling et al. 2003) and grammatical competence, with marked difficulties in tasks requiring the comprehension and especially the production of complex structures, which are demanding in terms of processing resources (Bar-Shalom et al., 1993, Byrne 1981; Waltzman and Cairns 2000, Mantione 2016, Robertson and Joanisse, 2010). Moreover, it has been suggested that the cognitive profile of dyslexics is also characterized by poor working memory resources and executive functions, which could be also held responsible for their difficulties in demanding tasks (Jeffrey and Everatt 2004; Vender 2017).

In the UK, the most widely accepted definition used in specialist teacher assessment is that provided by the Rose report (2009) and adopted by the British Dyslexia Association (BDA). In this report, dyslexia is defined as:

> *A learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling. Characteristic features of dyslexia are difficulties in phonological awareness, verbal memory and verbal processing speed. Dyslexia occurs across a range of intellectual abilities. It is best thought of as a continuum, not a distinct category, and there are not clear cut-off points. Co-occurring difficulties may be seen in aspects of language, motor co-ordination, mental calculation, concentration and personal organisation, but these are not, by themselves, markers of dyslexia. A good indication of the severity and persistence of dyslexic difficulties can be gained by examining how the individual responds or has responded to well-founded intervention.* (Rose, 2009: 30)

Insofar as dyslexia affects reading, opaque orthographical systems (like those of English or French) offer more difficulties than transparent systems (like those of Italian or Spanish), and this is pertinent to the introduction of modern language studies as a remediation tool, which is indeed recommended by the British Dyslexia Association (http://www.bdadyslexia.org.uk/educator/modern-foreign-languages). This cross-linguistic discrepancy in orthographical systems can be held responsible for the different percentages concerning the distribution of dyslexia that can be found across countries: in Italy, it is argued that dyslexia affects 3-4% of the population (www.aiditalia.org), whereas the percentage rises to 10% in the UK (http://www.bdadyslexia.org.uk/about); the NHS estimates that '1 out of every 10 or 20 people' show signs of dyslexia, which would put the number at 5-10% (https://www.nhs.uk/conditions/dyslexia/). Of course, this discrepancy does not imply that dyslexia is more widespread in one country than in another one; it simply reflects the fact that it is easier to detect reading difficulties in children whose mother-tongue has an opaque orthography. On the contrary, the difficulties experienced by those children whose mother-tongue has a transparent orthography may go unnoticed. The clear influence of orthographical opacity notwithstanding, the role of orthography should not be overestimated: although transparent languages have obvious advantages over opaque languages, it should be recognized that, whichever language is chosen, dyslexic learners are likely to experience difficulties in a range of areas including speed of information processing, language deficits in the comprehension and production of sentences requiring high processing costs, word retrieval, working memory and executive functions.

1.1. Comorbidities between dyslexia and other developmental disorders

Since dyslexia frequently appears in tandem with other disorders, it can be useful to briefly consider its comorbidities with other impairments. Being aware of the co-occurrence of these disorders is particularly important to develop a complete assessment of the child's abilities, which will permit the identification of her linguistic and cognitive profile in a more precise way and, importantly, also the development of more effective rehabilitation strategies, individually designed on the basis of her peculiar needs. The presence of an additional impairment, indeed, may affect the severity of the clinical picture: children with comorbidity, in fact, usually exhibit more severe neurocognitive impairment, negative academic experience, social outcomes and lower treatment response with respect to those without comorbidity (Margari et al. 2013).

First of all, dyslexia often co-occurs with other developmental learning disabilities, as *dysgraphia*, which is characterized by difficulties in the acquisition of writing skills (considering both spelling accuracy and handwriting or fine motricity problems), and *dyscalculia*, which is instead an impairment in mathematic skills. Landerl & Moll (2010) reported a four to five times increased rate of occurrence of these disorder in children already suffering from one learning disability, whereas Wilson et al. (2015) found a comorbidity rate of 40% for dyslexia and dyscalculia (see also Döhla & Heim 2016 for a discussion of the relationship between dyslexia and dysgraphia).

Moreover, dyslexia can appear in tandem with other disorders, including dyspraxia (coordination and movement impairment) and ADHD. According to the European Dyslexia Association:

> 50 % of persons with dyslexia are dyspraxic as well.
>
> 40 % of persons with dyspraxia are either dyslexic or have differences in attention.
>
> 85 % of persons with dysphasia are dyslexic as well.
>
> 20 % of persons with dyslexia present attentional problems with or without hyperactivity.
>
> 50 % of hyperactive children are dyslexic.

It is crucial to point out that in all cases we are dealing with dimensional disorders, each ranging from mild to severe. Also, as mentioned, it is difficult to find them in isolation.

Moreover, the degree to which dyslexia is confounded with other disorders makes it difficult to isolate the condition, especially with respect to Specific Language Impairment: due to the extensive overlap between these disorders, the relationship between them has been, and still is, object of a lively debate, as will be discussed in the following section.

1.1.1. Developmental Dyslexia and Specific Language Impairment

Specific Language Impairment (SLI) is a condition characterized by late emerging and protracted language acquisition relative to age expectations, without intellectual disability, autism diagnosis, hearing loss, or other obvious contributing conditions. The prevalence is estimated as 7% of 6-year-old children (Tomblin et al. 1997). The impairments involve both receptive and expressive language and include late talking and deficits

in grammar, vocabulary and discourse (Leonard et al.; 1992; Leonard et al. 1998; Leonard et al. 2000). Studies on twins show a heritability measure of between 0.50 and 0.97 for SLI (Bishop, 2002; De Thorne, 2006), particularly in populations which sought therapy (Bishop et al., 2008). Family aggregation studies document increased risk for SLI among siblings and parents of affected children. Twenty-two percent of nuclear family members of SLI probands are reported with a positive history compared to 7% of control families (Rice et al. 2009), with a similar range of affectedness across studies (Tomblin et al. 1996; 1997). Like dyslexia, SLI has a strong genetic component (Bishop, 2006), and it is usually recognized that genetic mutations, developmental factors, and hereditary influences all play a role.

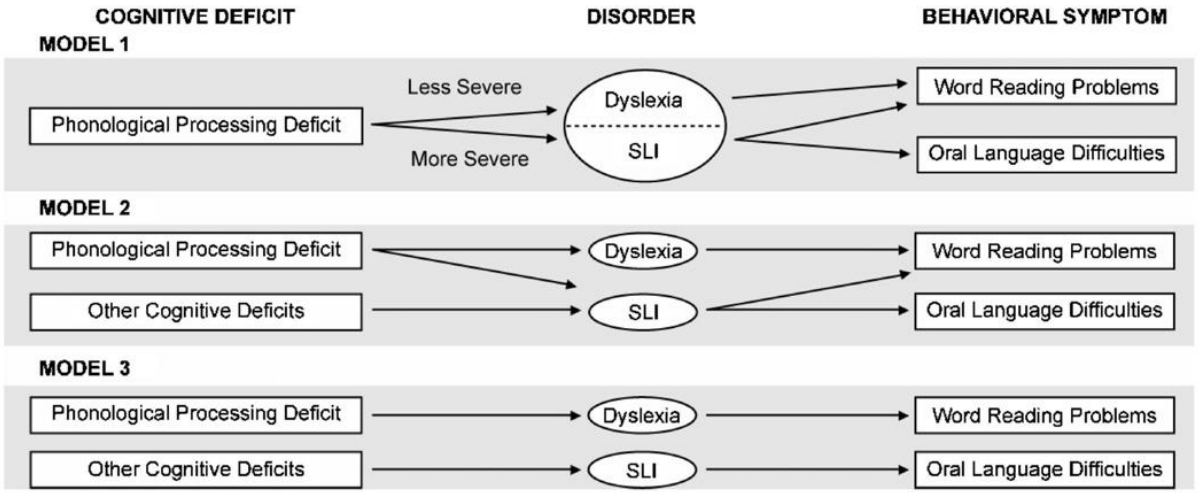
Historically, the terms 'developmental dysphasia' or 'developmental aphasia' were used to describe children with the clinical picture of SLI (Ingram and Reid, 1956). In medical circles, terms such as *developmental language disorder* (DLD), as suggested in Bishop et al. (2016), are often used due to controversy about aspects of the diagnosis, particularly, the lack of agreement on the criteria for the label SLI (see, e.g., https://www.afasic.org.uk/about-talking/types-of-slcn/what-is-sli/; also https://www.rcslt.org/clinical_resources/language_disorder/overview). In the UK educational system, *speech, language and communication needs* (SLCN) is currently the term of choice, but this is far broader than SLI, and includes children with speech and language difficulties (including all communicative difficulties, some of which can be extra-linguistic as in the case of ASD) arising from a wide range of causes.

Lexical and morphosyntactic difficulties are generally taken to be indicators of SLI in monolingual children, but the scenario gets more complicated when considering bilingual or multilingual children, as will be discussed in **section 2**.

As mentioned above, the relationship between dyslexia and SLI is currently object of a lively debate. According to the classification system used in clinical circles, SLI and dyslexia are both 'neurodevelopmental disorders': they are likely to be heritable (such that 66% of parents with reading difficulties (RD) will have a child with RD; Bonfacci et al., 2014), manifest early in development, and persist across the life-span. Early and accurate diagnosis is thus paramount, although this is, as we will see shortly, not free of problems. Equally important is to provide adequate intervention and early treatment, in order to reduce their impact. A major obstacle, however, is a lack of agreement as to how to identify and subsequently remediate these problems, not least because of confusion over definitions and terminology (Bishop et al., 2016). First, neither disorder is a 'category'; rather –as mentioned above- these are dimensional disorders, ranging from mild to severe with no clear cut-off between 'typical' and 'impaired' in either language or reading. Furthermore, there are common impairments to both disorders, which obscures dissociation; and not all children present the same profile of difficulties: for SLI, this has often meant excluding children from the category when they may in fact have the same difficulties or benefit from the same types of interventions as children who do meet the criteria. Catts et al. (2010) report that approximately 15-20% of children identified with dyslexia (in second, fourth, or eighth grades) met the criteria for SLI in kindergarten; higher rates had been reported in previous studies (McArthur et al., 2000), but there seems to be a big influence of issues pertaining to the selection of participants in the

results. Conversely, between 17 and 29% of children with SLI in kindergarten met criteria for dyslexia in later grades, depending on whether more conservative or more liberal criteria are considered.

Catts et al. (2010) present three models for the relation between dyslexia and SLI, which make different predictions about the diagnosis in case there are common symptoms:



Only Model 3 predicts that, if an SLI child presents word reading problems there is a dyslexic component (if there is an overlap between both disorders, it must be due to comorbidity), whereas the other two models, crucially, allow for an interaction between the two disorders. Such an interaction, from a formal point of view, can be accounted for if a single computational procedure is in play, which manifests in different ways depending on interactions between cognitive modules. Common components, however, can be addressed in a unified way. Model 1 studies dyslexia and SLI as part of a continuum, having the same underlying cause. This model predicts a great degree of overlap between dyslexia and SLI, attributing the behavioral impairments to strictly phonological deficits. Model 2 also assumes a degree of overlap between dyslexia and SLI, although it recognizes the existence of 'other cognitive deficits' as a possible cause for SLI. However, the disorders would be distinct in that children with SLI would have difficulties in oral language, and those with dyslexia would show normal or at least low normal development in this area. In Models 1 and 2, however, the co-occurrence between dyslexia and other kinds of impairments (dyscalculia, dyspraxia) as well as short-term memory and attention deficits is left unaddressed.

Bishop and Snowling (2004), who propose a model of the second kind, consider the question of whether SLI and dyslexia should be unified. Despite some behavioral similarities, they propose that it is useful to keep them apart in terms of symptom identification and dissociation. Specifically, they propose that

> *though there are close behavioral similarities between SLI and dyslexia, it is helpful to retain a distinction between relatively restricted problems with literacy and difficulties that encompass production and comprehension of spoken language. In the field of dyslexia, there has been an overwhelming emphasis on poor phonological processing as a cause of reading difficulties. However, study of children with oral language problems indicates that difficulties with semantics, syntax, and*

> *discourse will also affect literacy acquisition; in some children (so-called poor comprehenders) these difficulties may occur without any phonological impairment. In more classic cases of SLI, there can be both phonological and nonphonological language impairments that affect learning to read. Our working model shows dyslexia and SLI, not on a single continuum, but rather occupying different areas of a two-dimensional space.* (Bishop & Snowling, 2004: 858)

Similarly, from the point of view of phonology, Marshall et al. (2014) found that many children with SLI had some difficulties with the requirements of a place assimilation task in English, whereas children with dyslexia did not differ from age-matched control children. Similar results were reported by Blomert et al. (2004) for Dutch. These studies show normal compensation for place assimilation in dyslexic children, in two Germanic languages that have place assimilation processes, whereas SLI children's performance is indeed impaired. There seems to be thus some empirical grounds to maintain a distinction between the disorders, at least behaviorally.

From a computational point of view, however, it is interesting to inquire into the underlying processes that may be common to both disorders: a formal inquiry into the properties of the system that underlies morphological and phonological deficits, as well as some of the comorbid disorders (dyspraxia, dyscalculia), can shed light on the development of language-independent probes, which would address some of the problems raised by the adequate identification of SLI and dyslexia in multilingual environments. Catts et al. (2005) also conclude that SLI and dyslexia are distinct but potentially comorbid developmental language disorders. Children with SLI exhibit deficits in semantics, syntax, and discourse in the presence of normal nonverbal cognitive abilities, whereas the main aspect of dyslexia pertains to written language (word recognition and spelling) and phonological processing. In terms of phonology, problems pertain to *phonological awareness*, that is, awareness about the phonological structure of the language. This, together with deficits in phonological memory, makes it difficult for dyslexics to perform in non-word repetition tasks. However, studies have shown that the difficulties for dyslexics are not always limited to phonology and written language: children with dyslexia may also have problems in semantics, syntax, and discourse (Catts, Fey, Tomblin, & Zhang, 1999; McArthur, Hogben, Edwards, Health, & Mengler, 2000; Plaza, Cohen, & Chevrie-Muller, 2001). However, when present, these difficulties are not severe enough for the children to be diagnosed with SLI. By the same token, SLI children present difficulties with phonological awareness and phonological memory, which has been attributed to deficits in working memory, which could account for their poor performance in non-word repetition tasks. Also, studies have shown that children with SLI often present difficulties in learning to recognize printed words. For example, Tallal et al. (1988) found that approximately 67% of children with SLI at 4 years of age showed low achievement in word recognition at age 8.

Contemporary models of phonological competence are computational, and this has roughly been the case since the late 60s. This approach has been extended to cognitive deficits in general and is consistent with the observation of atypical phonological memory in both dyslexia and SLI, as well as a high correlation with ADHD. Understanding the nature of the formal computational properties that must be appealed to in order to

account for the behaviors observed in both typical and DLD populations provides important insights into the shared aspects of the disorders and aids in developing targeted assessment and intervention, as will be discussed in **section 3**.

1.2. Morphological competence as a relevant predictor for reading ability in dyslexic and unimpaired children

In **section 1** we provided evidence that dyslexia is more than just a reading disability, affecting also the domain of linguistic competence and of cognitive functions. We will now focus on morphological awareness, which has been reported to play a major role in the development of reading abilities (**section 1.2.1**) and to be significantly compromised in dyslexia (**section 1.2.2**). Interestingly, moreover, this skill has been found to be enhanced in bilingual children, both typically developing and suffering from developmental dyslexia (**section 2**). Based on this, we suggest that morphological training constitutes an integral part of an effective remediation treatment for dyslexia, based on the data found in some recent rehabilitation studies highlighting the importance of morphological intervention in the improvement of literacy achievements.

1.2.1. The role of morphological awareness in reading

Educators are generally much more familiar with the concepts of phonemes and phonological awareness than with those of morphemes and morphological awareness. The reason for this discrepancy lies in the fact that phonological awareness is generally seen as the most crucial component of literacy acquisition, whereas the role of morphological awareness is much less recognized and well known. Nevertheless, as we will discuss in this section, morphological awareness is able to provide a unique and important contribution to the development of reading and spelling skills, confirming that it plays a crucial role in reading acquisition and instruction.

Morphological awareness can be defined as the ability to consciously access the morphological structure of words and to reflect on it, or to analyze and manipulate the morphemes making up words. Since it involves reflection on language and its use, it is considered one of the *metalinguistic abilities* (Gombert 1992). Morphological abilities develop gradually from early childhood: at the age of two or three years old children typically start to experiment with different morpheme combinations, can create compound words and display a surprising creativity in their ability to combine morphemes inventing novel words to express meanings for which they lack an appropriate term (Clark 1982).

Although morphology actually comprises inflection, derivation and compounding, acquisition studies have focused principally on inflectional morphology, which indeed plays a crucial role in language acquisition from an early age (Leonard et al. 1990). Even in preschool years, children are able to identify morphemes, both inflections and derivations, and are able to apply inflectional rules (Carlisle 2003). In this respect, a distinction must be made between inflection of regular and irregular forms: according to the "dual-route hypothesis" (Pinker 1999, Pinker and Ullman 2002), there are two separate mechanisms, one characterizing regular inflections and based on the productive application of rules, and the other referring to irregular inflections and

based on the lookup of memorized forms stored in the mental lexicon. The main difference between regular and irregular forms is that the class of regular items is open-ended and highly productive, as demonstrated by the quantity of recently coined new forms (e.g email > emails), whereas irregular words define a closed class and their inflection is unpredictable and non-systematic (e.g. wife > wives). Consequently, irregular forms must be memorized and stored in the lexicon as pairs of ordinary lexical items and they must be retrieved from the lexicon when needed. On the contrary, the inflection of regular words is computed by mental operations through the application of the relevant rule. As a consequence, regular suffixes can be added to any new word, even to invented words.

The ability to produce the correct regular inflections of novel or unfamiliar words is in place at a very young age, as demonstrated by Berko (1958), who invented a famous experiment to show that even preschool children possess and are able to apply productive rules to generate inflections of novel words. The great merit of Berko's study lies in the idea of testing for knowledge of morphological rules by using nonsense material. If a child can supply the correct plural form of an existing word, such as *dishes* for *dish*, in fact, we do not have uncontroversial evidence to affirm that she has correctly applied the rule: indeed, she could simply have memorized the plural as a gestalt and retrieved it from her lexicon, instead of producing it by applying the rule. Conversely, if she produces the correct plural of a non-word, such as **lishes* for **lish*, we have rather uncontroversial evidence that she actually possesses and is able to apply the inflection rules for English plurals. Starting from these considerations, Berko designed a test aiming to assess children's ability to generate inflections, comprising plural words, singular and plural possessives, comparative and superlative forms of adjectives, progressive and past forms of verbs. The ability to analyze compound words was also tested. In this task, which has been further used and replicated in different studies, the subject is shown pictures portraying objects, cartoon-like animals and men performing various actions with a text typed on each card. In the typical example, which gave its name to the test, a little bird-like invented animal named "wug" was portrayed on the card, immediately followed by two identical animals, with the following text, uttered aloud by the experimenter: "This is a *wug*. Now there is another one. There are two of them. There are two…". The subject's task was to complete the sentence by producing the correct plural form of the given non-word (e.g. *wugs*). Results showed that even preschool children were able to generate the correct inflections, demonstrating that they do possess morphological rules of extension that enable them to deal with novel words. Furthermore, Berko found an improvement in first-grade children in comparison to preschoolers: the answers of the two groups were qualitatively similar, i.e. both employed the same morphological rules, and the improvement was more in the direction of perfecting knowledge that they already had as preschoolers.

This last outcome, which suggests an enhancement in morphological abilities related to the child's age and exposure to literacy, is in line with the results of several more recent studies showing that the major change in the development of morphological skills in children can be traced back to the moment they enter school.

A number of studies demonstrate that both phonological and morphological awareness support the process of learning to decode written words: if phonological skills are preeminent in the early stages of reading

acquisition, morphological and grammatical awareness become gradually more important as children move beyond their first few years of school. As they learn to read and spell, indeed, children become more skilled in tasks asking them to define the meaning of base words and to analyze morphologically complex words such as compounds or derivations. Specifically, first-grade pupils at the beginning of their schooling are less prone to decompose the word in morphemes or to use analogy to infer the meaning of complex items in comparison to fifth-grade children with higher literacy skills (Anglin 1993). Similarly, it has been found that fourth graders have lower morphological awareness skills that sixth and eight graders (Tyler and Nagy 1989, Wysocki and Jenkins 1987). This increase in their morphological abilities is generally attributed to the need of accessing the articulated structure of words and to understand the complex relation between form and meaning that has a central role in reading. Consistently, adult proficient readers rely more heavily on metalinguistic skills (e.g. morphological awareness, syntactic awareness and vocabulary knowledge) in comparison to beginning readers and the role of these language skills grows in predicting reading comprehension with age (Braze et al. 2007, Johnston et al. 2008). In contrast, the influence of phonological awareness, which has a well-documented importance in the first phases of reading instruction, diminishes with age, since more advanced reading comprehension demands language-based and cognitive skills.

Further evidence suggesting that there is an intimate connection between reading achievements and morphological awareness is provided by a number of correlational studies. One of the first studies addressing this issue was conducted by Brittain (1970) who measured morphological abilities by testing the inflectional performance of children with a revised version of the task constructed by Berko, and then analyzed its correlation with their reading achievements. In her task, the author used only inflectional items, in order to increase the purity of the test as an inflectional measure, and found indeed a significant relationship between reading ability and inflectional performance, even after intelligence was controlled, demonstrating that morphology has a structural significance in the process of learning to read.

Similarly, two longitudinal studies conducted by Tornéus (1987) and Carlisle (1995) reported that morphological awareness skills of kindergarten children were able to predict their reading abilities in the second grade. Interestingly, the magnitude of the correlations increases with age, suggesting that the predictive role of morphological skills on reading and comprehension abilities grows through scholastic grades and in adulthood (Guo et al. 2011).

It has been reported that both inflectional and derivational morphology are able to predict reading success, even though mastery of derivational morphology is accomplished later and follows a longer and more open-ended course (Mahony 1994, Singson 2000). Carlisle (2000) had the merit to assess directly the association between awareness of the structure of morphologically complex words, the ability to define them and reading skills, reporting that these aspects are strongly related. Moreover, even though morphological abilities are more pronounced in older children in comparison to younger children, it is nonetheless significantly associated with reading at any age.

Importantly, morphological awareness is able to predict real word and nonword reading even after controlling for other factors that are generally associated with reading achievements, such as intelligence level, phonological awareness, naming speed and orthographic knowledge (Singson et al. 2000, Kirby et al. 2012).

Another way to analyze the relationship between morphological awareness and reading is that of considering the effects of a specific morphological training on literacy development. Although research on morphological awareness instruction is still at an early stage, this seems a very promising line of investigation: preliminary results, indeed, reveal that a specific training in morphological awareness is associated with enhancement in word reading and spelling at any age, even in kindergartners (see Carlisle 2010 for a comprehensive and critical review). Moreover, helping pupils to adopt a strategy of morphological analysis of words leads to both an enhancement in vocabulary growth and to an ameliorative effect in reading comprehension, as demonstrated by correlational studies showing a robust association between morphological awareness and vocabulary, and between morphological awareness and reading comprehension (Mahony 1994, Wagner et al. 2007).

All in all, evidence from the first studies in this domain suggest that morphological training produces some benefits on reading independently of phonological abilities, thus suggesting that morphological awareness could even be a compensatory strategy for reading difficulties (see **section 3**).

1.2.2. Morphological deficits in developmental dyslexia

A number of studies have reported that morphological competence is remarkably impaired in dyslexia.

Joanisse and colleagues (2000), administered a test on inflectional morphology based on Berko's *Wug Test* in order to evaluate dyslexic children's abilities to apply past tense agreement rules and plural rules to both familiar words and nonwords and reported that dyslexics performed remarkably worse than age-matched controls on both tasks. Similarly, Jiménez et al. (2004) tested gender and number agreement and found that children with reading disabilities had a very poor performance, committing more errors than chronological age-matched controls and even than reading age-matched controls in all tasks. A morphosyntactic impairment has been detected also by Rispens (2004), who found that dyslexic children underperformed in comparison to controls in the grammaticality judgment task, failing to recognize subject-verb agreement errors.

Casalis and colleagues (2004) analyzed the morphological abilities of a group of dyslexic children, comparing their performance to that of two groups of typically developing children respectively matched for reading and chronological age in a series of morphological tasks. The authors found that dyslexics displayed a different profile in comparison to typically developing children, performing more poorly than chronologically age-matched controls and also than reading-age matched controls in tasks requiring the isolation or blending of morphemes, thus indicating that their difficulties were not simply due to a poorer reading experience. Moreover, the results of a regression analysis conducted on the data indicated that morphological skills develop independently from phonological skills.

These considerations are also in line with the results of the study conducted by Elbro and Arnbak (1996) who analyzed the effects of morphological training in dyslexia, reporting that morphological awareness can be

specifically trained in dyslexic children leading to better reading and spelling skills and thus suggesting that morphology may even become a compensatory strategy for their reading difficulties in dyslexia, as will be discussed more thoroughly in **section 3**.

A more recent study developed by Vender et al. (2017) within the European Project AThEME (Advancing the European Multilingual Experience) confirmed the presence of morphological deficits in dyslexic children: the authors administered a pluralization task to 52 Italian children divided into two groups: 24 children with developmental dyslexia (mean age 10.0 years old) and 28 typically developing children (mean age 9.11 years old). The task had the aim of testing the subjects' ability to apply pluralization rules to non-words in the morphologically complex context of Italian nominal inflection. Taking Berko's original paradigm as a basis, the authors adapted it to the more complex context of Italian inflection system, in which plurals are obtained by modifying the phonological shape of the singular ending in accordance with the declension class and gender feature of the stem. In their study, the authors compared the performance of dyslexics and controls in five conditions, corresponding to the different declension classes of Italian and characterized by distinct levels of complexity, as briefly summarized in (1), with an existing noun for each of the relevant declension classes reported in brackets.

(1) Conditions

(i) Condition 1: Feminine a > e, e.g. la muv-a > le muv-e (Class I, e.g. la port-a > le port-e, 'door')

(ii) Condition 2: Masculine o > i, e.g. il fol-o > i fol-i (Class II, e.g. il gall-o > i gall-i, 'rooster')

(iii) Condition 3: Masculine a > i, e.g. il tred-a > i tred-i (Class IV, e.g. il pirat-a > i pirat-i, 'pirate')

(iv) Condition 4: Masculine e > i, e.g. il dort-e > i dort-i (Class III masc., e.g. il pesc-e > i pesc-i, 'fish')

(v) Condition 5: Feminine e > i, e.g. la stab-e > le stab-i (Class III fem., e.g. la nav-e > le nav-i, 'boat').

Conditions 1 and 2, which correspond respectively to Class I and II of Italian nominal morphology, are fully productive, predominant in the input and extremely salient from the acquisition perspective, due to their high regularity and predictability (Dressler and Thornton 1996; among others). Moreover, they show maximal discrepancy in gender and in phonological form (a > e – o > i). On the contrary, Conditions 4 and 5 comprise items belonging to Class III, which is consistent with respect to number inflection, but totally unproductive and completely independent from gender specification. A noun ending in −e can be either masculine or feminine and takes the corresponding plural ending in −i independently of the stem's gender. Therefore, differently from Class I and II, there is no systematic gender-based rule or pattern for class determination. Finally, Condition 3, which corresponds to Class IV of Italian morphology, is numerically less pervasive than Class III, but opaque as far as gender manifestation is concerned. The majority of Italian nouns ending in −a are indeed feminine, whereas those in this class are masculine: hence, the learner must pay attention to agreement patterns in the singular to disentangle gender specification and devious phonological exponence, learning to produce the target plural marker −i. Given the peculiarities of these declension classes of Italian, Conditions 3, 4 and 5 were expected to be more challenging than Conditions 1 and 2. Consistently, the authors

found that dyslexics performed significantly worse than controls, especially in Conditions 1, 2 and 3, suggesting that their morphological skills are less sophisticated than those of unimpaired children.
In Conditions 4 and 5, instead, the two groups of children showed a similar and particularly inaccurate behavior, especially in the last condition, confirming thus that the relevant morphological rules were more difficult to apply to non-words. Moreover, a series of regression analyses confirmed that morphological competence plays a causal role in determining the child's reading skills: specifically, the subject's ability to pluralize non-words is able to predict accuracy in word reading, even after controlling for phonological awareness and working memory skills.

All in all, the results of the studies reviewed above confirm that morphological competence is significantly impaired in dyslexic children. Moreover, the causal relationship found between morphological awareness and reading abilities reported by these works suggests that a specific training of the subjects' morphological skills could have a positive impact on their reading performance, as will be discussed in section 3.

2. The interaction between language disorders and bilingualism

Given this state of affairs, the introduction of multilingualism as a variable only adds to the confusion, since it is not always clear whether a specific difficulty (particularly in younger populations) is due to the distinct linguistic trajectory in monolinguals and bilinguals or to a developmental condition: the (crucial) difference between delay and disorder is not always clear-cut in practice, unless a specific battery of tests is administered to the children. Actually, one of the major difficulties reported by teachers and educators concerns the identification of language impairments in bilinguals and Early Second Language Learners (EL2), as bilingual children can present language difficulties early on even if unimpaired. It is known, in fact, that both children and adult bilinguals often perform more poorly in comparison to their monolingual peers in specific language domains. They generally have a smaller vocabulary in both languages than comparable monolingual speakers and perform more poorly in standardized receptive vocabulary tests (Bialystok et al. 2010); moreover, their lexical access seems also to be slower and less accurate in comparison to that shown by monolinguals (Bialystok et al. 2008). Additional deficits have been reported in the domain of morphosyntax, especially in those tasks which require high processing costs to be accomplished (Serratrice et al. 2004, Sorace et al. 2009, Sorace 2011, Vender et al. 2016).

In this respect, Vender et al., (2014, 2016) point out that it is difficult to understand if the linguistic anomalies observed in bilingual children are due to the presence of a language impairment or if they are more simply the consequence of a still immature linguistic competence. As a consequence, over-diagnosing and under-diagnosing is a rather common problem. The scarcity of specific probing tools for bilingual and multilingual children (which need to incorporate language-specific consideration) only makes matters more complex. Marinis et al. (2017) point out that over- and under-representation of bilingual children with SLI occurs because language acquisition in bilingual children differs from monolingual children and thus monolingual norms cannot be used for bilingual children. Moreover, bilingual children's language trajectory is modulated

by environmental factors over and above those relevant to monolingual children. Among these, Marinis and colleagues list onset and exposure to the two languages, quantity/quality of input, and status of the language pair (minority/majority); these factors lead to greater individual variability than in monolingual children.

Recently, there has been an increasing reliance on *clinical markers*, language-specific structures that are particularly problematic for SLI children, and which may allow researchers to identify SLI children from normally developing children. Vender et al. (2014, 2016) present and discuss two of these markers for Italian: direct object clitic pronouns and non-word repetition, providing also insight on the most usual mistakes made by L2 speakers of different languages, in order to distinguish them from impaired children. Results reveal that even early L2 (EL2) children with a recent exposure to Italian and different first languages as a background perform similarly to monolinguals in non-word repetition tasks, which are instead extremely challenging for children with SLI. Moreover, even though both EL2 children and SLI children exhibit difficulties in clitic production, analyzing the typology of errors committed by the children would permit to discriminate the two populations and to identify SLI also in bilingual children.

Another problem to be addressed is the overall lack of standardized assessment tasks in more than one language; an issue that could be partially circumvented if language-independent tasks entered the picture, including artificial grammar learning (AGL) tasks (see, e.g., Saddy, 2009, Shirley, 2014, Phillips, 2017). In this context, understanding the formal properties of different kinds of artificial grammars is paramount in devising appropriately varied tasks which target distinct computational dependencies; Saddy & Krivochen (2017), **a work developed within AthEME**, provide a classification of mutually irreducible formal systems which allows the experimenter to tailor AGL tasks to specific kinds of computational dependencies in order to have a better understanding of the which processes they can expect to be impaired in language-specific tasks. It must be stressed that useful as they are, AGL tasks alone cannot do the trick given the variety of linguistic conditions (for instance, the influence of orthographical systems, the different kinds of structural dependencies preferred in different languages, etc.): language-independent tasks must be supplemented with language-specific tasks once a computational difficulty (e.g., pertaining to the assignment of structural descriptions to stimuli) has been found by means of language-independent probes.

Finally, it is worth underlying that bilingualism must not be discouraged in children with dyslexia and SLI: a document elaborated by the British organization *Afasic* (https://www.afasic.org.uk/) explicitly warns about the perils of excluding children with recognized speech and language difficulties from a specific category solely on the basis of their being bilingual, and the need to tailor remediation procedures to their needs,

Bilingual children with language impairment should receive input in the language of education as well as their home language to ensure that they do not lose it or become socially isolated from their immediate and extended family.

This is particularly worth emphasizing, since parents, educators, educators, speech therapists and teachers often fear that bilingualism could exacerbate the difficulties of their impaired children, and impact negatively

on their linguistic competence in the majority language. Conversely, a considerable body of evidence indicates that bilingualism can provide positive effects both on the linguistic and on the cognitive domain (see section 2.) and that, crucially, these effects extend also to linguistically impaired children. The conclusion emerging from these preliminary results is thus that bilingualism can be seen as an opportunity to catch, even in the case of communicative impairment and developmental language pathologies.

2.1. The benefits of bilingualism

Recent research shows that bilingualism (or multilingualism) may provide advantage to children with language impairment, in both the linguistic and the cognitive domain. Specifically, bilinguals, including children, adults and elderly people, have been found to perform better in tasks that involve the suppression of irrelevant information and conflict resolution both with linguistic stimuli and with non-linguistic ones. Tasks in which an advantage of bilingualism has been consistently reported to outperform monolingual are the Stroop task, (Bialystok et al. 2008), the ANT task (Costa et al. 2008) and the Simon task (Martin & Bialystok 2003; Bialystok et al. 2004).

The advantages of bilingualism in the cognitive domain are arguably related to the fact that a bilingual has to constantly deal with two languages in her mind: this fact does not affect only her language processing abilities but, crucially, also her cognitive skills and EF. Indeed, both languages are always jointly activated, thus creating a competition that the bilingual has to solve by inhibiting the interference of the language that she is not using in a specific moment. Therefore, bilinguals have been proposed to develop a stronger ability than monolinguals in inhibiting the access to the non-relevant language and in focusing selective attention to the relevant one (Bialystok et al. 2009). Since inhibition and selective attention are part of the EF system (Miyake et al. 2000), it has been proposed that bilingualism affects also the domain of EF, a claim that has been supported by a number of studies reporting enhanced EF in bilingualism (Bialystok et al. 2008; Costa et al. 2008; amongst others).

The question as to whether these advantages extend also to impaired children has only recently been addressed. Indeed, both dyslexics and SLI children have been found impaired in the domain of executive functions and typically struggle in comparison to their typically developed peers in demanding tasks such as the Stroop Task and the Simon Task (**Vender et al., in prep; both studies have been conducted within AThEME project**). Interestingly, the first results suggest that the benefits of bilingualism extend also to impaired children. Specifically, bilingual SLI children have been found to perform more similarly to monolingual controls in the *flanker task* (which involves suppressing incongruent stimuli with respect to a target in specific contexts) although worse than bilingual controls (Engel de Abreu et al., 2014). Similarly, bilingual children with dyslexia have been found to outperform monolingual children with dyslexia in a version of the Simon Task created according to the rules of an artificial grammar, which has been elaborated and administered **thanks to the collaboration of the Universities of Verona and Reading within AThEME (Vender et al. in prep)**, as well as in the Stroop Task **(Vender et al. in prep; research conducted within AThEME project).**

Beyond the cognitive domain, significant advantages of bilingualism have been reported in the linguistic domain too. For the purposes of this paper, we will focus more thoroughly on metalinguistic awareness and morphological competence, in which bilingual children, both typically developing and suffering from dyslexia, have been found to outperform their monolingual peers.

2.2. Metalinguistic and morphological awareness in bilingualism: an advantage which extends also to dyslexia

Metalinguistic awareness and morphological skills have been reported to be particularly enhanced in bilingualism. As Vygotsky (1962) first underlined, bilinguals appear to be more familiar with the arbitrariness of the relationship between meaning and form in comparison to monolinguals, and therefore they are less reluctant to separate them. This consideration was confirmed by Bialystok (1986) who found that bilingual children were more competent than monolinguals in accepting grammatically well-formed but semantically anomalous sentences (e.g. *Apples grow on noses*), displaying therefore a better ability to separate form and content, which was taken to attest their more sophisticated metalinguistic awareness. This metalinguistic advantage has been explained by arguing that bilingualism seems to guarantee a higher symbolic flexibility, allowing children to experience an accelerated separation of meaning and form and to focus their attention on language form (Cummins 1978). Another example of a metalinguistic task tapping morphological skills in which bilinguals have been reported to show advantages in comparison to monolinguals is the Wug Test, which was designed by Berko (1958) with the aim of assessing monolingual children's ability to generate inflections in English by means of non-words.

Barac and Bialystok (2012) administered the Wug Test and two tasks assessing language proficiency (i.e. receptive vocabulary and grammatical ability) to a group of monolingual children and three groups of age-matched bilinguals (Spanish-English, French-English and Chinese-English), with the aim of comparing bilinguals and monolinguals, considering also other effects such as language similarity (Spanish and French are more similar to English than Chinese) and language of schooling (English for the vehicular language for Spanish L1 and Chinese L1 children, whereas French was used for the French L1 children). The authors found that the Spanish-English children, who did not differ in language proficiency from the monolinguals, outperformed them in the Wug Test, showing higher morphological abilities. Conversely, the other two groups of bilinguals performed worse than monolinguals in language proficiency, but their performance was better in the Wug Test than in the tasks tapping their language competence more directly. The differences between the groups of bilinguals were ascribed to the fact that only the Spanish-English bilinguals could have benefitted from both the linguistic similarity between Spanish and English and the use of English as language of instruction, whereas the other two groups could not take advantage of at least one of these essential aspects.

Bialystok et al. (2014) investigated whether a bilingual advantage arose also in second language learners, by testing two groups of English children acquiring French in an immersion education program and attending to the second and fifth grade. They found that all bilingual children outperformed monolinguals in the Wug Test, whereas only the older bilingual children were more accurate than the monolinguals in a sentence-judgment

task. Results suggest that the bilingual advantage emerges earlier and more clearly in the Wug Test, which can be considered less complex than the other task, since there is no misleading information to be filtered out or any need for particularly effortful processing (Bialystok et al. 2014).

Summarizing, the studies reviewed in this section suggest that bilinguals, having access to two different linguistic systems, are prompted to develop a more sophisticated ability to focus and reflect on the structures of their languages in comparison to monolinguals.

On this background, **Vender and colleagues (2018) carried out a research within the European project AThEME** aiming at investigating whether the advantages reported in bilingual typically developing children extend also to linguistically impaired subjects, as dyslexics. The same task developed by Vender et al. (2017) and discussed above, analyzing the participants ability to generate plural noun inflections of nonwords, was administered to 106 children: 24 Italian monolingual dyslexics (mean age 10;0 y.o.), 30 Italian monolingual typically developing children (10;1), 22 bilingual dyslexic children with Italian as L2 (10;4) and 30 bilingual typically developing children with Italian as L2 (10;2). The authors found that bilinguals performed better than monolinguals, irrespective of dyslexia, thus pointing to a general advantage of bilingualism which also extends to dyslexia. Indeed, the BD displayed higher accuracy than the MD, performing similarly to the two control groups. Analyzing each condition, no differences were reported in F a > e, where all groups manifested a similarly accurate performance, whereas differences arose in M o > i, with dyslexics performing worse than controls. In this case, the presence of a significant interaction between bilingualism and dyslexia reveals that the effect of dyslexia, which has a negative impact on performance, is limited to monolingual children, indicating thus a positive effect of bilingualism in dyslexia. In M a > i, instead, we found only a significant effect of dyslexia, which suggests that dyslexics, irrespective of bilingualism, performed more poorly than controls. This result confirms the previous one reported by Vender et al. (2017) and is arguably due to the lower 'type' frequency of nouns belonging to Class IV in Italian and to its opacity for what concerns gender; this is also supported by the fact that M a > i is the only condition in which all groups of children did not reach a 100% accuracy with words. In condition M e > I and F e > i, instead, results reveal a marked positive effect of bilingualism, without any effect of dyslexia. As in the previous study, MD performed more poorly than MC, but this difference is not statistically significant, whereas both groups of bilinguals outperformed monolinguals, suggesting that bilingualism enhances morphological skills, increasing the sensitivity to the relevant rules and the ability to apply them in online processing.

These results thus point to an advantage of bilingualism in morphological competence that crucially extends to dyslexia: in the most difficult conditions, indeed, bilingual dyslexics performed even better than monolingual unimpaired children, indicating that their ability to apply morphological rules in an abstract way across the board, based on the input provided to them by their second language, and more particularly the ability to apply them to novel words, was significantly better not only with respect to monolingual dyslexics, but also with respect to monolingual typically developing children.

This study has been successfully replicated by Melloni et al. (forthcoming), again within the AThEME project, who have administered the same pluralization task, with a few minor modifications, to two groups of typically

developing bilingual children, having either Romanian or Albanian as their first language, reporting an advantage of both groups of bilingual children over their monolingual peers and therefore suggesting that the benefits of bilingualism are independent from factors like language similarity.

3. Treatment of dyslexia: an overview

Despite the increasingly urgent need to develop effective tools for the treatment of dyslexia, since now remarkably limited research has focused on remediation therapies for this disorder. On the total output of publications and research studies on dyslexia, only less than 1% concern the presentation and evaluation of rehabilitation programs (Bakker 2006). The reason for this probably lies in the lack of unanimous consensus about the etiology of dyslexia, leading researchers to concentrate their efforts on the understanding of the different manifestations characterizing this disorder and its possible causes, more than on the investigation of suitable treatment procedures.

Indeed, the different treatments that have been proposed, some of which are currently used by health professionals working on the rehabilitation of dyslexics' reading abilities, stem from the purpose of training the ability which is considered more severely compromised in dyslexia. Of course, since the major and the most invalidating deficit shown by dyslexics lies in the acquisition of proper reading skills, all types of treatment for dyslexia basically consist in the use of remediation tools developed with the purpose of enhancing the child's ability to read. However, there are several possible paths one can go through to get these results, clearly depending on the theoretical framework adopted to face dyslexia. For instance, supporters of the Phonological Deficit Hypothesis, which considers dyslexia as a disorder originating from an impairment of the subject's phonological competence, suggest to apply a phonological and sublexical treatment to help children overcoming their phonological deficits and gain better decoding abilities (Torgesen et al. 1997; see McArthur et al. 2012 for a systematic review). Specifically, this kind of treatment targeting phonological decoding seems to enhance the child's accuracy, more than their speed, in reading.

Conversely, based on the visual-deficit hypothesis, treatment should have the main goal of improving the efficiency of the lexical reading procedure, by training the necessary visual analysis skills; a number of studies have reported beneficial effects of specific kind of action video games, characterized by the presentation of multiple and rapidly moving stimuli, on dyslexics spatial and temporal attention, but also on their reading abilities, especially relative to the fluency parameter (Franceschini et al. 2017, amongst others).

A discussion of these kind of treatments falls beyond the purposes of this report. Conversely, given the advantages reported for bilingual dyslexic children in the morphological domain (see **section 2.2**) and the relevance of morphological awareness as a significant predictor of reading abilities (**section 1.2.1**), we will discuss more specifically the results of the studies focusing on morphological treatment for dyslexia, which seem to be particularly effective in enhancing reading accuracy and reading comprehension, both in unimpaired and impaired children.

First of all, however, it is fundamental to emphasize that the primary step of any successful treatment of dyslexia lies in the accurate definition of the disorder: on the basis of a careful examination of the cognitive and linguistic profile of the dyslexic child established during the diagnostic procedure, the health professional must develop an individualized program, aiming at developing the child's weaknesses and at working on her strengths.

Moreover, in terms of organizations and policy makers, it is worth mentioning some institutions, like the European Dyslexia Association (EDA) and the British Dyslexia Association (BDA), which are particularly sensitive to this topic. The European Dyslexia Association is a NGO comprising several regional organizations whose aim is to bring together research, policy making, as well as patients. It was founded and legally established under Belgium law in 1987 in Brussels as an international non-profit association by representatives of ten national dyslexia associations. "*It is the platform and the Voice of the people with dyslexia and so called 'Specific Learning Difficulties' in Europe.*" (http://www.eda-info.eu/). The main goals of EDA is to inform people, politicians, policy makers, trade and commerce unions and pressure groups in Europe about the necessity of supporting those who are dyslexic or DYS in a positive way, in order to avoid negative consequences caused by inappropriate education and training, low self-esteem and under-achievement, which may lead to social exclusion.

The BDA, instead, provides resources for teachers at different levels, from pre-school to secondary school, including information as to how to access screening, and introductory material to make all members of the educative community (teachers, parents, students) aware of what dyslexia is, how to pre-empt misconceptions about the disorder, and how to help children best. The site also provides material on neurodiversity (including, for instance, ASD), more generally, as part of a set of core resources that the general public can have access to.

Finally, the UK government webpage (www.gov.uk) provides information as to how to apply for Access Arrangements, which allow candidates/learners with special educational needs, disabilities or temporary injuries to access the assessment without changing the demands of the assessment. Similarly, there is information about special educational needs and disabilities (SEND). These include:

- behavior or ability to socialize, for example they struggle to make friends
- reading and writing, for example because they have dyslexia
- ability to understand things
- concentration levels, for example because they have ADHD
- physical ability

Thus, the disorders we are considering here are indeed taken into account, at least on paper, in the UK curriculum. There does not seem to be any specific policy regarding Key Stage 2 (ages 7-11), which is a critical stage for recognition and treatment so as to maximize the results of intervention. As a matter of fact, studies show that age 10 is too late for ideal treatment of dyslexia since emotional, social and academic failure have

already accumulated by this age. Late diagnosis is definitely a problem to be addressed as part of policy making, and requires the interaction of researchers, teachers, and the Government in terms of informing not only scientifically sound policy, but also realistic ways to optimize academic performance for SLI and dyslexic children.

3.1. Morphological training as a promising rehabilitation tool for dyslexia

In **section 1.2.1** we reported that morphological awareness is able to predict reading and spelling outcomes effectively and independently from other variables like phonological awareness and working memory. In spite of the growing awareness of its importance for the development of literacy skills, morphological awareness has received less attention by researchers and educators interested in the rehabilitation of reading related disorders like dyslexia.

One of the first works providing evidence of a morphological intervention for the rehabilitation of dyslexia was performed by Elbro & Arnbak (1996). In a first study they asked subjects, 26 dyslexics and 26 younger children matched for reading level, to read aloud single words, including both words with a semantically transparent morphological structures (e.g. sunburn) and words with a non-transparent structure (e.g. window). Although the stimuli were matched for phonological complexity and for length, they found that dyslexic children were more affected by the morphological structure of the words, reading those with a transparent morphological structure less effortlessly than the non-transparent ones. This difference was instead not observed in controls, who read equally well both types of stimuli, suggesting that dyslexics performed a sort of morphological analysis to compensate for their poor phonological decoding skills.

In a subsequent online study, they administered to 16 dyslexics and 16 controls matched for reading age a self-paced reading task in which the child had to read 90 sentences in different conditions: letter-by-letter, syllable-by-syllable, morpheme-by-morpheme, word-by-word or with the whole passage presented at one time. The idea was that of verifying whether some linguistic units were more supportive and beneficial for reading than others. Actually, the authors reported that dyslexics had better results when reading texts morpheme-by-morpheme, suggesting that written morpheme recognition could be a viable strategy for dyslexics to compensate for their phonological difficulties in decoding texts.

In a following study, then, Elbro & Arnbak (1996) assessed the benefits of morphological instruction during classes, reporting that dyslexics who received a specific morphological training, characterized by segmentation and semantic reflections on compounds, derivational affixes and inflections, achieved higher levels of morphological awareness in comparison to dyslexics which received standard remediation classes on reading, with positive effect of the treatment being more visible in the accuracy of spelling and in passage comprehension than in pure decoding.

These promising results opened the way to a number of studies exploring the effectiveness of morphological intervention to improve literacy achievement, both in normally developing and in struggling readers. In a recent synthesis, Reed (2008) analyzed the results of 7 published studies investigating the effects of morphological

instruction in English, directed to both normal and poor readers, on three reading outcomes including word identification, spelling and vocabulary development. The considered treatments focused primarily on morphology instruction, including roots and affixes, and produced positive effects, especially with poor readers, suggesting that targeting students with reading difficulties could yield stronger effects. Abbott and Berninger (1999), for instance, considered two groups of low-achieving readers, proposing to the first a traditional phonological/alphabetic intervention, and to the second a treatment characterized by 15 minutes of the *Words* program (Henry 1990), with explicit instruction in syllable types and morpheme patterns, for a total of 16 hours. Children, in particular, were encouraged to reflect on syllable structure and morpheme pattern and they were taught to divide the word in syllables, checking also for roots and affixes. The authors found that children improved significantly in reading and reading-related measures, and that morphological treatment was as effective as the traditional phonological/alphabetic treatment proposed to the control group.

Another comprehensive meta-analysis conducted by Bowers, Kirby and Deacon (2010) considered the results of 22 studies examining the effectiveness of morphological instruction with both poor and good readers, from preschool to upper elementary schools, and across a variety of languages (English, Danish, Dutch and Norwegian). As in Reed (2008), all studies used morphological analysis tasks in which children were asked to identify the morphemes composing morphologically complex words. Berninger et al. (2003), for instance, asked students to decide which word "come from the other word" in word pairs like *respectfully/respect* and *pillow/pill*. Morphological production was also included, as in the study by Nunes et al. (2003) in which students were asked to produce the derivation of a word based on analogy with a given derivation (e.g. sing → singer; magic → ?). Moreover, as already underlined by Reed (2008), Bowers and colleagues (2010) confirm that the benefits produced by a specific morphological instruction are even stronger on average in groups of poor readers.

The final meta-analysis that we will consider in this review, developed by Goodwin and Ahn (2010) focuses specifically on dyslexic children and poor readers, reporting the results of 17 independent studies investigating the effects of morphological training on literacy outcomes for students with difficulties in literacy. They reported that morphological instruction can successfully improve reading and spelling at the sublexical, lexical and supralexical levels for struggling readers and spellers, indicating that it should be included in remediation therapies, and that it could also be embedded in classroom teaching across grade levels, stimulating students to focus on the meaning of each morpheme in complex words, which could likely lead to a more efficient learning.

Moreover, morphological instruction showed a significant improvement also on literacy related skills, including phonological and morphological awareness, which are, as discussed above, key processes in the acquisition of reading and spelling, and on reading comprehension too, suggesting that improvements in sublexical processing or in vocabulary lead students to better comprehend text.

As a final consideration, the results of the meta-analyses reviewed here unanimously reported that the effects of morphological instruction were stronger for less able children, suggesting that morphology is likely to be a

relative strength for struggling readers. Casalis et al. (2004), indeed, proposed that dyslexics, as well as poor readers, may rely more on morphological knowledge as a compensatory strategy for their shaky phonological competence. In other words, they could learn to develop higher quality lexical representations, in spite of their phonological deficits, thanks to an explicit instruction in morphological structure building up an integrated lexical representation of semantic cues and orthographic patterns, which could then be associated to the corresponding phonological form (Bowers et al. 2010). Moreover, reaching a higher metalinguistic awareness about the morphemic structure of words could increase the motivation of struggling readers, who typically experience more frustrations in schools in trying to understand how sounds have to be translated in letters.

Even though between bilingualism and children's acquisition of literacy in their second language have not been explicitly addressed in research on morphological training, and, more generally, remediation therapies for dyslexia, we believe that morphological intervention could be very beneficial for early second language learners too, especially if they struggle with the acquisition of literacy. Indeed, it could be even more effective for bilingual children, helping them to develop appropriate strategies to deal with complex words, considering reading, spelling and comprehension, and compensating for their vocabulary weaknesses. Morphological instruction can namely have the additional important advantage of exposing children to a wider and more sophisticated vocabulary. Studying morphological families of words, (sign → design, designate, insignia, significantly, assignment; cf. Bowers et al. 2010) and focusing on their structures and their meaning connections, could indeed help both poor readers and bilinguals, who typically have a poorer vocabulary characterized by both length and frequency effects, build a richer lexicon.

In conclusion, training paradigms which focus on morphological awareness seem to be particularly promising for the treatment of dyslexia, both in monolingual and bilingual children, although further studies across age and ability levels are required. Therefore, we strongly encourage future research to develop and assess morphological treatment procedures targeting both monolingual and bilingual children, with and without a diagnosis of dyslexia.

3.2. Other possible strategies of remediation: Executive Functions and Artificial Grammar Learning

So far, we have focused on the analysis of intervention programs based on specific languages. However, we also believe that language independent paradigms based on simple formal grammars (of the kind used in Saddy, 2009; Shirley 2014 and more recently Phillips, 2017; Saddy & Krivochen, 2017) can address the underpinnings of cognitive deficits, as explored by **research conducted by Krivochen and Saddy at the University of Reading within the AThEME Project**. Such approaches allow for the targeted manipulation of syntax (structure and manipulation of symbolic representations) and executive function, including attention, learning, memory and adaptation through subtle changes in the formalism used to generate the experimental stimuli. The conventional explanation of the bilingual advantage mentioned earlier is based on the observation that if one has two languages in their linguistic tool box then one language must regularly have to be suppressed in favor of the other thereby developing and honing executive control abilities. The application of AGL methods

embraces this characterization and provides a tightly controlled set of mechanisms that allow the component parts of attention and executive control to be targeted and exercised. In particular such protocols can be finely tuned based on an understanding of the mathematical properties of the artificial grammars that are used, and determine structural similarities between specific artificial grammar paradigms and specific structural dependencies present in natural languages. Thus the application of AGLs based on very simple formal grammars (minimizing the number of distinct symbols and rules to the bare minimum while still delivering non-trivial structural patterns) can serve as a language intervention tool that accommodates to the children's limited access to linguistic resources. The possibility of offering tasks in a variety of modalities (visual and auditory, as well as combinations of these) serves the purpose of eliminating confounding variables when accounting for the participants' behavior.

Tasks aimed at measuring executive control function are also relevant, given the central role that EF plays in reading comprehension. Horowitz-Krauz et al. (2014) have shown that 8-12 year-old children with RD showed greater reading and EF improvement after 4 weeks of training with an EF-based reading program; a language-independent task based on artificial grammar learning paradigms emerges as a natural companion to reading tasks aimed at improving EF. Diamond et al. (2011) also show the beneficial effect of EF training in 4-6 year-old children on future academic abilities.

Based on these results, we propose that also this kind of strategies could be worth pursuing in order to target individual differences in dyslexic children and students.

4. Conclusion

In this report, we aimed at providing a review of the remediation therapies generally used in the rehabilitation of developmental dyslexia, focusing in particular on morphological instruction as a promising strategy for compensating dyslexics phonological deficits and enhancing their reading and spelling abilities. We began our discussion underlying the importance of morphological awareness in predicting literacy outcomes, and presenting the results of the studies that we performed within the European Project AThEME, evidencing a deficit of morphological competence in dyslexia but also an advantage in morphological tasks for bilingual children, both dyslexics and typically developing, over their monolingual peers. Based on these results, and on the analysis of studies discussing the benefits of morphological instruction, we proposed that a morphological treatment could be particularly effective for the rehabilitation of reading disorders, both in monolingual and in bilingual children, leading to enhancements in reading and spelling skills, but also in phonological and morphological competence, vocabulary development and reading comprehension.

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