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The Role of Morphology in Literacy Acquisition in Dyslexic Readers

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Developmental dyslexia is a disorder in the acquisition of written language which negatively affects word recognition and spelling (Lyon, Shaywitz, & Shaywitz 2003). These difficulties are probably related to phonological disorders, which disrupt the matching of graphemic units to phonemic units (Ramus 2014, Snowling 2000). Despite these phonological disorders, several studies show that dyslexic students do process the morphological structure of words in spoken and written language. The aim of this chapter is to show how and under what conditions dyslexic students process derivational morphemes when they are reading and writing them. ¹

1. Developmental Dyslexia

While most readers recognize words instantly and automatically, some readers encounter persistent difficulties in learning to recognize words. These difficulties are often related to factors such as intellectual disability, inadequate schooling, or a less stimulating environment. When children still fail to learn to read even though these factors are not present, they are said to display developmental dyslexia. International classifications, such as DSM-5 or ICD-10 have developed a definition of this learning disability based on exclusion criteria, defining it as a lasting and massive failure of the development of word

¹ Several studies have also been conducted in children with delayed reading but not diagnosed as dyslexic. Nevertheless, this chapter concerns only research conducted with dyslexic participants.

recognition despite a non-verbal level of reasoning in the norm; an absence of sensory or neurological deficit; and a favorable social, cultural and psychological environment (International Dyslexia Association 2002; World Health Organization 2011). A diagnosis is made after eliminating other potential sources of difficulty in learning to read, and after confirming a reading delay of a minimum of 18 months (or 24 months in children over nine years of age) (Casalis, 2014). According to an epidemiological study of children from White Island (Yule, Rutter, Berger, & Thomson, 1974), dyslexia affects 5 percent of school-age children, i.e., approximately one per school class (Sprenger-Charolles & Colé, 2003).

The difficulties encountered by dyslexic students stem from a disorder which affects the recognition of written words, a skill that children must master to become proficient readers (Gough & Tunmer, 1986). Although several hypotheses have been proposed to explain these difficulties, currently, the most accepted is that of a phonological deficit interfering with the development and/or access to phonological representations (Boets *et al.*, 2013; Ramus, 2014; Saksida *et al.*, 2016; Snowling, 2000). This phonological deficit disrupts the phonological decoding process, which consists of matching graphemes to their corresponding phonemes. According to the hypothesis of self-teaching proposed by Share (1995), the development of the orthographic lexicon is based on the successful decoding of words. This decoding allows the reader to associate the orthographic form of words with their phonological representations. Consequently, the orthographic lexicon cannot develop correctly in dyslexic students (Share, 1995), which prevents the automatization of written word recognition and disrupts performance in written production (Share, 1999; Shahar-

Yames & Share, 2008). These difficulties are likely to lead to problems in written comprehension (de Oliveira, da Silva, Dias, Seabra, & Macedo, 2014) and to limit vocabulary growth (Stanovich, 1986; Ziegler, Perry, & Zorzi, 2014).

Strategies in dyslexic readers

Despite a persistent phonological deficit, some people with dyslexia develop reading skills that exceed expectations, given their difficulties with phonological decoding, and go on to pursue studies at the postsecondary level (Bruck, 1992). These dyslexic students likely rely on skills that partially bypass their phonological deficit and which allow them to read reasonably proficiently.

Among the hypotheses put forward to explain how dyslexic readers compensate for their phonological deficit, Stanovich (1980) proposed that they rely more heavily on contextual cues contained in written texts than normally-developing readers, which enables them to read the words by guessing. Reading is an interactive activity that involves low-level (e.g., decoding) and high-level (e.g., knowledge mobilization, semantic anticipation, context use) processes that operate in parallel and allow written messages to be understood. Several sources of information – phonological, orthographic, semantic and syntactic – are synthesized simultaneously. Difficulties in low-level processing (i.e., decoding difficulties) can therefore be compensated for by higher-level processing, via context activation. Several studies have shown that weak decoders rely more on contextual information to recognize words (Ben-Dror, Pollatsek, & Scarpati, 1991, Bruck, 1990, Nation & Snowling, 1998, Stanovich, West & Feeman, 1981).

Dyslexic readers also draw on their greater sensitivity to the orthographic characteristics of words. In fact, dyslexic readers score higher than children with the same reading level for orthographic awareness, defined as “knowledge of the actual spelling of particular words and higher level conceptual skills, such as the recognition of the properties of words and sequences and typical positions of letters” (Siegel, Share, & Geva, 1995, p. 250). They are also more competent than their peers at judging between two plausible pseudowords which could be a word from the letters that constitute it, while remaining less proficient at decoding them. In addition, dyslexics’ spelling skills are sometimes superior to those of reading-matched children, especially in dyslexic children whose difficulties cannot be explained by a lack of exposure to writing (Stanovich, Siegel, & Gottardo, 1997). They have been found to recognize the letters presented in a text more quickly and accurately (Steinhauser & Guthrie, 1974, according to Siegel *et al.*, 1995). Finally, they are faster than children matched for reading ability at selecting the correct spelling of a word when presented with a pseudo-homophone (e.g., rain vs. rane) (Olson, Wise, Conners, Rack, & Fulker, 1989). Although there are few of these studies, they indicate that, despite their difficulties in manipulating the phonological structure of the language, dyslexic students develop a sensitivity to the probabilities of association between letters and store the orthographic form of words in memory.

Dyslexic readers thus seem able to compensate for their phonological deficits by relying more on contextual clues to read, and/or paying more attention to the sequences of letters of words. Another type of reading strategy based on the processing of written morphemic units was proposed by Elbro and Arnbak (1996). Most alphabetic systems encode not only

phonological information, but also morphological information. According to Elbro and Arnbak (1996), dyslexic children could preferentially orient to these units to process written language. The aim of this chapter is to present a set of studies that suggest that dyslexic students develop morphological knowledge, that they can manipulate oral morphemic units, and that they process these units when recognizing and producing words in writing.

From a methodological point of view, the study of morphological processing in dyslexic students involves comparing their performance with two control groups: a group of children matched for chronological age, and a group of children matched for reading and/or spelling level (according to the dimension studied, Casalis, Colé & Sopo, 2004). The use of the age-matched control group determines whether the performance of dyslexic children is within normal parameters or delayed for their age. The use of a control group matched for the studied dimension (reading/writing) makes it possible to determine whether difficulties are the consequence of their reading delay (in which case there would be no significant differences between the two groups' performance) or the consequence of a deficit (in which case the scores of dyslexic children would be lower than those of the control group). The studies presented in this chapter will therefore be organized according to the comparison group used. To highlight possible developmental effects in dyslexic children's morphological processing (e.g., effect of age and/or exposure to written language), findings will also be presented according to the age group under study (children, adolescents, and adults).

2. Morphological awareness and dyslexia

Morphological awareness is defined as the “conscious awareness of the morphemic structure of words and their ability to reflect on and manipulate that structure” (Carlisle, 1995, p. 194). It influences different domains of literacy acquisition, including: children’s ability to read both morphologically simple words (Carlisle & Nomanbhoy, 1993 ; Casalis & Louis Alexandre, 2000 ; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009) as well as morphologically complex words (Carlisle, 2000; Nagy, Berninger, & Abbott, 2006); the reading of pseudowords (Deacon & Kirby, 2004; Mann & Singson, 2003; Singson, Mahony & Mann, 2000), written comprehension (Carlisle 1995; Casalis & Louis Alexandre 2000; Deacon & Kirby, 2004), written production (Casalis, Deacon & Pacton, 2011, Fejzo, 2016) and vocabulary acquisition (McBride-Chang, Wagner, Muse, Chow, & Shu, 2015).

Development of morphological awareness in dyslexic readers: hypotheses

Two hypotheses have been proposed regarding the development of morphological awareness in dyslexic readers (Casalis *et al.*, 2004). According to the first hypothesis, the phonological deficit of dyslexic readers could hinder the development of oral morphological representations. This hypothesis is based on the idea that phonological awareness is inextricably linked with the development of morphological awareness (Carlisle & Nomanbhoy, 1993; Carlisle, 1995; Casalis & Colé, 2009 ; Casalis & Louis Alexandre, 2000 ; Fowler & Liberman, 1995).

According to a second hypothesis, morphological awareness could develop at least partially independently from phonological awareness (Casalis *et al.*, 2004). Although it is difficult to disentangle these two types of metalinguistic knowledge, regression analyses show that morphological awareness explains a portion of the variance in reading scores that is distinct from the portion explained by phonological awareness (Carlisle & Nomanbhoy 1993; Carlisle 1995; Shankweiler *et al.*, 1995). Moreover, phonological training has no impact on the ability to produce a suffixed form when given a base form (e.g., young: “the man remembers his ___(youth)”) in French prereaders (Casalis & Colé, 2009). This result confirms the hypothesis that the overlap between phonological and morphological skills is only partial (Casalis & Colé, 2009). In addition, children with repeated mild otitis (which theoretically decreases auditory acuity thereby causing phonological processing disorders) can process the morphological structure of words to the same extent as children who are not struggling with this type of problem (Breadmore & Carroll, 2016). This finding reinforces the idea that phonological and morphological processing are at least partially independent from each other. Therefore, morphological knowledge could influence the acquisition of written language in individuals who have a deficit in phonological awareness, such as children with dyslexia.

Several authors have hypothesized that dyslexic children’s oral comprehension skills allow them to develop knowledge of the morphological structure of language via the meanings of morphemes (Casalis *et al.*, 2004; Elbro & Arnbak, 1996). If the development of morphological representations is based on mapping units that systematically share form and semantic properties (Rastle & Davis, 2008, Schreuder & Baayen, 1995, Verhoeven &

Perfetti, 2011), in order for dyslexic readers to develop morphological representations, they may rely more heavily on their preserved sensitivity to the semantic context. Their development of morphological awareness could also be mediated by vocabulary development, since the ability to develop vocabulary also remains intact in dyslexics (Cavalli, Duncan, Elbro, El Ahmadi, & Colé, 2016, Vellutino, Scanlon, & Spearing, 1995).

Morphological awareness in dyslexic readers: comparison with age-matched controls

From an empirical point of view, most studies that compare dyslexic children with chronically age-matched children indicate a delay in the development of morphological awareness. Dyslexic children encounter difficulties with tasks involving the activation of knowledge related to morpheme association rules (Berthiaume & Daigle, 2014), as well as tasks involving manipulation of morphemes (Casalis *et al.*, 2004; Siegel, 2008), but not in tasks that involve memorizing morphologically complex words (Service & Tujulin, 2002).

Dyslexic adolescents also experience more difficulties than their peers of the same chronological age when performing morphological awareness tasks. At the age of 13, English-speaking dyslexic adolescents make more mistakes when attempting to complete sentences with a derived form (e.g., care. The road is narrow here, so please be _____ (careful)) or with a base (e.g., weakness. After being sick for many days, he was very _____(weak)) (Tsesmeli & Seymour, 2006). Hebrew-speaking dyslexic adolescents also make more mistakes than age-matched adolescents when choosing the correct form in an analogy task (reading : reader (textbook); the washing : _____ (cleanliness / reader

(person) / laundry/ restriction / laundress)) (Schiff, Cohen, Ben-Artzi, Sasson, & Ravid, 2016). Finally, Chinese-speaking dyslexic adolescents score lower than the normal readers of the same chronological age when completing a sentence with a word consisting of two morphemes (Chung, Ho, Chan, Tsang, & Lee, 2011, see also Shu, McBride-Chang, Wu, & Liu, 2006).

Finally, in dyslexic adults, different results were reported according to language. In English, the performance of dyslexic university students is lower than that of students of the same age (Law, Wouters, & Ghesquière, 2015). For French, dyslexic students' level of morphological awareness is not significantly different from that of students of the same age but not dyslexic in terms of accuracy (Cavalli, *et al.*, 2016, Martin, Frauenfelder, & Colé, 2014) whereas their scores on phonological awareness tasks are lower. However, they are slower to perform certain tasks involving the deletion of suffixes (Martin *et al.*, 2014) and the detection of suffixed words (Cavalli *et al.*, 2016).

Morphological awareness in dyslexic readers: comparison with reading-matched controls

Comparison of dyslexic readers' morphological awareness with that of children with the same level of reading yields more contrasting results. Dyslexic readers' scores depend on the skills required to perform the task. For tasks which rely heavily on phonological skills (e.g., manipulating pseudowords, "a little trine is a ____ trinette"), the scores of dyslexic children are lower than that those of children matched for reading level (average chronological age: 7 years 3 months, Casalis *et al.*, 2004). The influence of phonological

skills is further confirmed when the dyslexic children are divided into two subgroups according to the extent of their phonological disorder ("phonological" type dyslexia and "delay" type dyslexia). In this case, dyslexics with the most pronounced phonological deficit experience more difficulty in producing morphologically complex pseudowords (Casalis *et al.*, 2004).

On the other hand, when morphological awareness tasks do not involve maintaining a pseudoword in short-term memory or producing one, the performances of dyslexic children are no different from than those of children matched for reading level (Berthiaume & Daigle, 2014, Casalis *et al.*, 2004, Fowler & Liberman, 1995). For example, on tasks involving vocabulary that is accessible to dyslexic children, their performances are equivalent to or better than those of children with the same level of reading. When they must produce derived words (e.g., five – fifth), they are no more penalized by the phonological and orthographic modifications of the base form than their reading-matched peers (Casalis *et al.*, 2004; Fowler & Liberman, 1995; Shankweiler *et al.*, 1995). In a morphological fluency task which requires the child to orally produce as many words of the same morphological family as they can think of, dyslexic children produce more morphologically related words than their reading-matched peers (Casalis *et al.*, 2004). Their performance is also superior when it comes to finding the derived pseudoword that does not fit with the others (e.g., *médaille-muraille-bataille-mangeaille* (medal-wall-battle-grub), *médaille* being the intruder)) or a suffixed word where the meaning of the suffix is different depending on the derived word (e.g., *arrosage-bavardage-voisinage-nettoyage* (watering-chatting-neighborhood-cleaning) (the suffix *-age* in *voisinage* means

“a set” compared to “the action of” in the other words) (Casalis, Mathiot, Becavin, & Colé, 2003). In summary, these studies show that the oral morphological skills of dyslexic children depend on the nature of the task and on the processes underlying the task.

The performance patterns of dyslexic adolescents are similar to those of dyslexic children. There is no distinction between their performance and the performance of younger children of the same reading level on a sentence-completion task involving a derived form (e.g., care. The road is narrow here, so please be _____ (careful)) or a base word (e.g., weakness. After being sick for many days, he was very _____ (weak)) (Tsesmeli & Seymour, 2006). Similar results have been reported for Chinese (Chung *et al.*, 2011) and Hebrew (Schiff *et al.*, 2016). However, the frequency of target words strongly influences dyslexics performances on these tasks (Tsesmeli & Seymour, 2006). This reinforces the idea that the morphological abilities of dyslexics are strongly related to their level of vocabulary.

In dyslexic adults, the results depend on the language under study. In French, their morphological skills are superior to what would be expected given their reading level. They are faster and more accurate than reading-matched peers (who are also matched for phonological awareness) at performing a task where they must identify prefixed words (e.g., endive - envol – enclume: envol (endive - flight – anvil)) and suffixed words (e.g., lanière - tanière – glacière: glacière (lanyard - den – cooler)) (Martin *et al.*, 2014). However, this strong effect for morphological structure has not been observed in dyslexic adults in Hebrew: in a study using the same analogy task as Schiff *et al* (2016), Ravid *et*

al. (2007) showed that dyslexic adults make more mistakes than younger children of the same reading level.

Influence of morphological awareness on literacy in dyslexic readers

The influence of morphological knowledge on dyslexic readers' literacy acquisition has been the subject of very few studies. To our knowledge, only Law *et al.* (2015) took an interest in this issue. In their study of dyslexic university students, morphological awareness was a better predictor of reading, spelling and reading comprehension levels than vocabulary or phonological awareness (Law *et al.*, 2015).

To summarize, these results indicate that dyslexic readers demonstrate a higher degree of morphological sensitivity than one might expect given their phonological deficit, at least when tasks are not too costly in terms of phonological manipulation. The findings indicate that the skills of dyslexic readers are equivalent to, or better than, those of reading-matched children, suggesting that to some extent, morphological skills operate independently from phonological awareness. Dyslexic readers' morphological awareness appears to be particularly developed when it comes to using vocabulary and / or knowledge about the meaning of morphemes. In adulthood, contradictory results were reported according to language. Studies found that performances of French-speaking adults with dyslexia continued to improve into adulthood: their performances were indistinguishable from those of age-matched readers. For other languages, dyslexic adults were less proficient than their age-matched peers at manipulating the morphological structure of oral words. In the case

of Hebrew, dyslexic adults also scored lower than their reading-matched peers. Finally, consistent with findings for normally-developing readers, morphological skills were also found to predict reading level.

3. Morphemes as reading units in dyslexics

Recognizing written words is a process that requires the reader to use written stimulus to map visual representations with their corresponding representations stored in memory. Over the past 40 years, many studies conducted among expert readers have shown that the recognition of morphologically complex words involves their decomposition into morphemic units (Frost & Grainger, 2000; Longtin, Segui, & Hallé, 2003; Rastle, Davis, Marslen-Wilson, & Tyler, 2000; Schreuder & Baayen, 1995; Taft, 1979). Children's ability to process the morphological structure of words appears rather early in reading development (Beyersmann, Castles, & Coltheart, 2012; Burani, Marcolini, & Stella, 2002; Carlisle & Stone, 2005; Colé, Bouton, Leuwers, Casalis, & Sprenger-Charolles, 2012; Deacon, Campbell, Tamminga, & Kirby, 2010; Quémart, Casalis, & Duncan, 2012), even before the mastering of phonological decoding (Marec-Breton, Colé & Gombert, 2005). Since morphological processing of writing is not based solely on phonological decoding skills, dyslexic readers may benefit from the presence of morphemic units in word recognition.

Elbro (1990, reported by Elbro & Arnbak, 1996) was the first to propose the idea that dyslexic readers' morphological knowledge could be used to compensate for their

difficulties in manipulating phonological units when recognizing spoken words. The possibility of identifying groups of letters associated with meaning – morphemes – could improve the reading skills of dyslexic children by facilitating access not only to lexical representations (Burani, Marcolini, De Luca, & Zoccolotti, 2008) but also to the meaning of words (Elbro & Arnbak, 1996). This hypothesis is supported by research which indicates that dyslexic readers do develop morphological representations (Casalis *et al.*, 2004; Martin *et al.*, 2014). It is also supported by studies which have shown that morphological awareness explains a significant portion of variance in reading scores, above and beyond the variance explained by phonological awareness (Carlisle & Nomanbhoy, 1993; Casalis & Louis Alexandre, 2000; Deacon & Kirby, 2004).

Morphology and young dyslexic readers

To test this hypothesis in dyslexic children, most studies have used a task of naming (i.e. to read aloud) of morphologically simple and complex pseudowords. In a study involving French-speaking dyslexic children and reading-matched children, Casalis (1995) administered a task which involved reading three types of items: derived words (e.g., *classement* (ranking)); pseudowords made up of a base and a suffix (e.g., *écolerie*); and pseudowords made up of a pseudobase and a suffix (e.g., *elocerie*). Participants in both groups read more morphologically complex pseudowords (e.g., school) than pseudowords with no base form (e.g., *élocerie*). Morphological construction also had a more pronounced influence on the performances of dyslexic children than the performances of reading-matched controls. These results suggest that when dyslexic children encounter

pseudowords (i.e., new words), they are able to identify prominent units in them, i.e., the morphemes, on which to rely for easier access to the lexicon. An effect for pseudoword construction has also been demonstrated for words with more transparent spellings. For instance, dyslexic Italian-speaking children (aged between 11 and 12) read pseudowords composed of a base and suffix (e.g., *donn-ista*) more quickly and more accurately than simple pseudowords (e.g., *denn-osto*, Burani *et al.*, 2008 ; see also Traficante, Marcolini, Luci, Zoccolotti, & Burani, 2011). A similar effect has been observed in children matched on reading level and chronological age. On the other hand, only dyslexic children and reading-matched controls benefit from the presence of morphemes in terms of reading speed (Burani *et al.*, 2008). The presence of morphemes also facilitates the reading of pseudowords in Spanish-speaking children with dyslexia. The presence of more than one morpheme allows them to read pseudowords constructed with two morphemes (e.g., *plateza*) more quickly than morphologically simple pseudowords (e.g., *astoza*), and this effect is stronger in dyslexic children (aged from 7 to 10 years) than in children matched on chronological age (Suárez-Coalla & Cuetos, 2013).

Morphology and adolescent dyslexic readers

Elbro and Petersen (1993, reported by Elbro and Arnbak, 1996) used another method to investigate the role of morphological processing in word recognition by Danish dyslexic adolescents (aged 15 years on average). The researchers asked them to scroll through text on a computer screen using the mobile window method. They could scroll the text either syllable by syllable, morpheme by morpheme, or word by word. The results showed no

significant differences between dyslexic children and reading-matched controls in terms of text scrolling speed in the word by word condition. On the other hand, dyslexic adolescents scrolled faster than normo-readers in the morpheme by morpheme condition, and this pattern was reversed for the syllable by syllable condition. These results demonstrate dyslexic adolescents' preference for processing morphemic units as opposed to written syllabic units.

Morphology and adult dyslexic readers

Although effects of the morphological structure have been observed for children and adolescents, the same effects have not been demonstrated for English-speaking dyslexic adults attending university. In a lexical decision task, it was normo-readers matched for reading comprehension, and not dyslexic adults, who had faster response times for morphologically complex words (e.g. musical) than for morphologically simple but pseudo-derived words (e.g., metal, where *met-* and *-al* are respectively a base and a suffix in English) (Deacon, Parrila, & Kirby, 2006). However, these results were not compared to results for a control task involving morphologically simple words. However, as Burani *et al.* (2008) propose, dyslexic readers could benefit from the presence of morphemes as lexical units irrespective of their meaning, whether they are morphologically constructed or pseudoderived. Only comparing results with those obtained for a task involving simple words would have provided insight into the emergence of this type of processing. Thus, it is difficult to draw a clear conclusion from this study.

All these findings suggest that dyslexic readers – at least until adolescence – process words and pseudowords in terms of their morphological structure, and that they are able to do so with no additional processing costs in terms of observed speed.

Nature of morphological processing in dyslexic readers

Two sources of information encoded in morphemes could influence how dyslexic readers process the morphological structure of words: the semantic properties and/or the form properties of morphemes (Quémart & Casalis, 2015). If dyslexic readers draw principally on the semantic properties of morphemes, the way in which morphological representations are organized in the lexicon may be determined by the semantic links between words of the same morphological family. In this case, an effect would be observed when readers process words belonging to the same morphological family (e.g., helper-helpful) and that effect would vary according to the size (number of members) and frequency of this family. If dyslexic readers rely essentially on the form properties of morphemes, the organization of morphological representations in the lexicon would be influenced by the identification of lexical units formed by the same set of graphemes at the same position independently of their meaning overlap. In this case, if presented with a set of words that share a lexical unit but do not share a semantic link (e.g., *flag-flagon*), dyslexic readers would erroneously decompose the longer word into smaller units (i.e., flag-on).

The nature of the morphological processes that dyslexic readers use to recognize written words has been demonstrated through the use of test items that vary according to word transparency. The morphological construction of words is not always transparent: it varies

on a continuum from transparent to opaque. When the construction is semantically transparent, the meaning of the derived form can be predicted by its component morphemes, such as *nageur* in French (swimmer in English). However, some words are composed of a base and a suffix, but their meaning cannot be clearly inferred from its component morphemes. These words are semantically opaque. For example, the word *rideau* (curtain) is constructed with the base *ride* and the suffix –eau, but the meaning of *rideau* is no longer related to that of *ride*. Other words, "pseudoderived", include accidentally morphemic units that are not related to the word either from a semantic or etymological point of view (e.g., *baguette*). Morphological derivation can also lead to a form (orthographic or phonological) modification of the lexical base, which produces formally opaque words. For example, the phonological and orthographic form of the base *hôpital* (hospital) becomes *hospitalier* (hospitable) in its derived form.

Dyslexic readers are influenced by the semantic transparency of morphemes during morphological processing. Danish dyslexic adolescents read semantically transparent words (e.g., sunburn) more quickly and more accurately than semantically opaque compound words (e.g., window) (Elbro, 1990, in Elbro & Arnbak, 1996). Such an effect for transparency is not observed in children matched on reading level. These findings suggest a reading profile for dyslexic readers that is distinct from children of the same level of reading and which is characterized by a greater sensitivity to the semantic properties of morphemes. More recently, in a study involving French-speaking dyslexic children and children matched on reading and chronological age, Quémart and Casalis (2015) administered a lexical decision task based on the masked priming paradigm. In this

paradigm, the target is preceded by another stimulus, the prime, to observe its effect on how the target is processed. The prime is said to be "masked" when its presentation time is so short that it cannot be processed explicitly by the participant, which in turn reveals which properties of the prime are processed automatically. To examine how the semantic properties of morphemes are processed by dyslexic children, the authors proposed primes and targets that share a morphological link (e.g., *saladier-SALADE* (salad bowl - salad), a link of pseudoderivation (e.g., *mortier-MORT* (deadman-DEAD)), a purely orthographic link (e.g., *vendredi-VENDRE*, (Friday-SELL)) or a purely semantic link (e.g., *bouillon-SOUBE* (broth-SOUP)). The researchers found that patterns for effects of priming were different in the three groups: while children from the two control groups benefitted from the prime under the morphological and pseudoderived conditions, dyslexic children benefitted from the prime only in the morphological condition. The only difference between these two conditions lies in the semantic link between the prime and the target in the morphological condition. A surface morphological link between the prime and the target (such as that of the condition pseudoderivation) is not sufficient for dyslexic children to benefit from the presence of morphemes to recognize written words: the activation of the semantic properties of morphemes underlies this type of processing.

Dyslexic children are also affected by the form transparency of lexical bases. In a second study using the masked priming paradigm, Quémart and Casalis (2015) examined the processing of the form properties of morphemes. Targets and primes could share four relationships: morphological and transparent (e.g., *amoureux-AMOUR* (lover-LOVE)), morphological with only phonological modification (e.g., *bergerie-BERGER* (sheepfold-

SHEEP)), morphological with phonological and orthographic modification (e.g., *aviateur-AVION* (aviator-AIRPLANE) or purely orthographic (e.g., *fourmi-FOUR* (ant-OVEN). While the groups of children matched on reading and on chronological age benefitted from the prime only in the transparent morphological condition, dyslexic children benefitted from the prime in all three conditions despite form modifications of the lexical base between the prime and the target. Dyslexic children, therefore, tolerate more form modifications of the lexical base when recognizing written words.

These studies indicate that constituent morphemic units contained in words are activated when dyslexic readers (especially children and adolescents) are recognizing them. Activation of these units facilitates the recognition of written words with respect to a control condition where no morphemic unit is locatable. To achieve this processing, dyslexic readers seem to preferentially rely on the semantic properties of morphemes, a strategy which distinguishes them from normo-readers, who are more sensitive to the form properties of morphemes.

4. Morphemes as writing units in dyslexics

The ability to locate morphemic units in words makes it easier not only to recognize them, but also to recover their spelling from memory to produce them in writing. Most alphabetic systems represent not only phonological information, but also morphological information. From the age of 6, young writers take into account the presence of a base when choosing the orthography of a suffix (e.g., *smarter* vs. *corner*), or the presence of a suffix to choose

the spelling of graphemes that constitute the lexical base (e.g., turn in turning vs. turnip) (Casalis *et al.*, 2011; Deacon & Bryant, 2005, 2006). The ability to activate words from the same morphological family also makes it easier to spell words that are not morphologically complex but which end with a silent letter (e.g., bavard vs. foulard (chatterbox vs. scarf)) (Sénéchal, 2000).

There are few studies on the role of morphology in the written production of dyslexics. Dyslexic writers seem to draw on morphological information in the same way as children of the same reading age. In a study involving dyslexic adolescents, and groups of children matched for reading and chronological age respectively, Tsesmeli and Seymour (2006, 2009) asked English-speaking participants to spell either morphologically complex words (e.g., finally) or their lexical base (e.g., final). They measured morphological consistency, i.e. the percentage of graphemes that were spelled exactly the same way in the base word and in the morphologically complex word. The researchers found that dyslexic writers rely on morphological consistency to the same extent as younger children with the same level of reading, despite the scores of dyslexic writers being generally lower than that of the other two groups. Dyslexic children thus benefit from the morphological structure of words during their production. Similar results have been reported by Breadmore and Carroll (2016) in another study in English. In their study, participants had to complete written sentences with a pseudoword that was either morphologically simple (e.g., He called his pet rat Paoma) or morphologically complex (e.g., A person who soams is a soamer). The performance of dyslexic students did not differ from that of the reading controls, which confirms the results reported by Tsesmeli and Seymour (2006, 2009).

In other studies, the performances of dyslexic children were compared to those of children matched on spelling. In a written production task where participants had to recall the spelling of words that ended with final consonant clusters in English (e.g., bars), dyslexic children and spelling-matched children omitted fewer graphemes when those graphemes were part of a morphologically complex word (e.g., “r” in bars, where “bar” and “s” are two distinct morphemes) than when they were part of a simple word (e.g., “r” in Mars) (Bourassa, Treiman, & Kessler, 2006). Moreover, both groups of children made fewer mistakes when choosing the spelling of a grapheme that can be pronounced in several ways (e.g., "d" or "t", which can be pronounced /t/ or /d/ according to the words in which they appears) when the grapheme was part of a morphologically complex word (e.g., waiting) than when it was part of a morphologically simple word (e.g., beauty). Therefore, there are no meaningful differences between dyslexic children’s and younger spelling-matched children’s ability to use morphological knowledge to spell words (Bourassa *et al.*, 2006). In another study involving dyslexic children whose spelling level corresponded to the 2nd year of primary school, Bourassa, Deacon, Barga, and Delmonte (2011) cited by Bourassa and Treiman (2014) asked participants to spell morphologically simple words and morphologically complex words. The words all started with the same lexical base (e.g., trick) but had different endings: the morphologically complex words ended with a suffix (e.g., tricked; tricky) whereas the morphologically simple words ended with a sequence of letters not corresponding to a suffix (e.g., trickle). All participants (dyslexic and controls) spelled morphologically complex words more accurately than morphologically simple words. This result indicates once again that dyslexic writers take morphological information into account when they produce words, and that they do so in ways that are

similar younger spelling-matched children. This effect for the morphological structure was replicated in Greek by Diamanti, Goulandris, Stuart, and Campbell (2014) with dyslexic children between 10 and 13 years old and age-matched controls. They asked participants to write morphologically constructed adjectives. As in the studies by Bourassa *et al.* (2006, 2011), dyslexic children scored lower than age-matched children, but similarly to children of the same spelling level. Since Greek spelling is very transparent, this result suggests that morphemic processing in written production is also observed in instances when phoneme-grapheme correspondences are consistent.

Dyslexic writers may rely on the morphological structure of words when writing to a greater extent than expected, given their level of reading and spelling. Quémart and Casalis (2017) asked dyslexic children and adolescents (aged 10 to 15 years) and younger children matched on reading and spelling to produce words ending with a final silent letter. In the morphological condition, the choice of the final, silent letter could be disambiguated by using morphologically related words (e.g., *tricot* (knit), where the final “t” is pronounced in morphologically related words such as *tricoter* (to knit), and *tricoteur* (knitter)). In the control condition, the selected words did not belong to a morphological family (e.g., *effort*, “effort”). The results show that while dyslexic children scored lower overall than children in the control group, they performed similarly to children of the same level of reading and spelling when they could draw on morphologically related words.

In addition, the ability of dyslexic writers to use the morphological structure of words sometimes exceeds expectations given their lexical level. Angelelli, Marinelli, De

Salvatore, and Burani (2017) have shown that Italian dyslexic children benefit as much as children of the same chronological age from the morphological structure of words in their written production. They produce fewer errors when producing pseudowords constructed with two morphemes (e.g., *lampad-ista*) than pseudowords in which it is not possible to locate morphemic units (e.g., *livonosto*). This same effect is observed in dyslexic children and children of the same chronological age. It is also observed when the participants have to produce infrequent words constructed from frequent morphemic units (e.g., *brut-ezza* (ugliness)) in relation to words constructed from rarer morphemic units (e.g., *agrum-eto*, (citrus grove)). Thus, despite their delays in reading and spelling, dyslexic children perform similarly to children of the same chronological age when asked to produce morphologically complex words in writing.

To sum up, data on the written production of morphologically complex words indicate that the performances of dyslexic children match and sometimes exceed those of children matched on reading and / or spelling. These findings are particularly encouraging and coherent with those highlighted in the word recognition studies. These studies deserve to be replicated, especially in adult dyslexics, for whom spelling difficulties are persistent and quite resistant to intervention.

5. Conclusion

The objective of this chapter was to review how people with dyslexia process the morphological structure of words in different languages and in different domains related

to the acquisition of written language: morphological awareness, reading, and written production. Studies in this field are still rare, particularly in the field of reading and spelling production.

Given the variability observed between the different studies, it is difficult to formulate clear and unambiguous conclusions about the ability of dyslexics to process the morphological structure of the language. Nevertheless, the results are broadly convergent and indicate that people with dyslexia do not present specific deficits in this area. They can manipulate the morphological structure of the language orally, especially when the task draws on their vocabulary and/or semantic skills. The effects are also influenced by task requirements in terms of phonological manipulation.

The possibility of locating morphemic units in words also facilitates the reading of complex words compared to words that are morphologically simple. In addition, the nature of the processing used by dyslexic readers differs from that of normally-developing readers. Dyslexic readers preferentially rely on the semantic properties of morphemes to benefit from the morphological structure of words. In contrast, for normally-developing readers, the activation of morphological representations in memory seems to be based primarily on the form (orthographic and/or phonological) properties of morphemes. This pattern is consistent with findings from investigations of morphological awareness in the dyslexic population: the data indicate that dyslexic participants are particularly competent when performing tasks which require them to use their vocabulary (Casalis *et al.*, 2004). Further studies are needed to confirm this difference in processing between groups. They could

also clarify the differential role of vocabulary and semantic skills in the processing of the morphological structure of words by those with dyslexia.

Finally, the fact that dyslexic students' lexicons are structured around morphological representations facilitates the recovery of word spellings when they are asked to produce them in writing. Dyslexic writers can therefore partially overcome their spelling difficulties by relying on the morphological structure of the words.

These data have important implications at the theoretical level. Dyslexic readers' difficulties are best explained by their phonological disorders (Boets *et al.*, 2013, Ramus, 2014, Saksida *et al.*, 2016, Snowling, 2000). These disorders prevent them from implementing the grapho-phonemic conversion procedure, which disturbs the development of the orthographic lexicon (Share, 1995). However, the studies presented in this chapter also show that the development of literacy does not rest solely on phonological skills: morphological skills are also important contributors. Thus, the size of the units activated when processing written language varies not only according to orthographic consistency (Ziegler & Goswami, 2005, 2006) but also according to the reader's level of expertise with oral and / or written language. When dyslexic readers are unable to effectively establish grapho-phonemic correspondences, they turn to larger units: morphemes. This processing does not necessarily involve a fine coding of the exact letters in each morpheme, which leads them to be less sensitive than normally-developing readers to the inversions and / or transpositions of letters within a given morpheme (e.g., bain/baignoire (bath / bathtub); hôpital/hospitalier (hospital / hospitalable)) (Quémart & Casalis, 2015).

From a methodological point of view, these studies reinforce the need to compare the performances of dyslexic students with those of students matched on the dimension studied (reading and / or spelling level). This comparison group makes it possible to highlight the nature of the difficulties encountered by dyslexic students, but also the domains in which they have developed abilities that exceed expectations given their level of reading / spelling. Another important point concerns the type of task used to assess morphological abilities. Tasks that involve a strong phonological awareness component penalize dyslexics whereas their morphological abilities become evident when tasks solicit their vocabulary.

6. Practical implications

These data are particularly encouraging because they provide pathways for managing the difficulties of dyslexic students. The processing of morphological units is obviously not sufficient to completely overcome dyslexic students' disorders in reading and spelling. Nevertheless, training that targets the morphological skills that they do have is likely to be a good alternative to the traditional phonic method, which aims to develop the skills that are at the heart of dyslexic readers' challenges (McArthur *et al.* 2012). For example, Arnbak and Elbro (2000, see also Tsismeli & Seymour, 2007) carried out a study aimed at improving the morphological awareness of dyslexic readers through targeted training and examined the impact of that training on reading and spelling. The results are promising since participants showed an improvement in morphological awareness compared to control groups that did not receive training, as well as improvements in reading and

spelling. Goodwin and Ahn (2010) have also shown that training that targets morphological skills is of benefit to struggling readers, and favors the development of phonological awareness, morphological awareness and vocabulary.

In a meta-analysis published in 2010, Goodwin and Ahn proposed a synthesis of key factors contributing to the improvement of morphological skills in struggling readers. They found that interventions with the greatest effect lasted between 10 and 20 hours minimum and that the most effective exercises involved manipulations of the morphological structure of words in relation to reading, vocabulary acquisition, and writing. Tasks involving the manipulation of morphemes without linking to these domains were much less effective. Finally, the type of intervention (group or individual) has no significant influence on the effectiveness of training. These recommendations may guide practitioners who wish to offer morphological activities to their dyslexic students.

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