Reading comprehension: Individual differences, disorders, and underlying cognitive processes

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Abstract

Poor readers are classified as dyslexic readers when they show poor below age-average reading comprehension in the absence of general cognitive deficits. However, a diagnosis of dyslexia based on this definition bears no information about the cause of the individual reading deficit or the kind and extent of required intervention. Identifying the specific cause and severity of reading comprehension problems is essential to create adequate and target-oriented intervention programs for poor readers. This chapter provides an overview of the cognitive processes underlying reading comprehension and discusses how reading disorders can be characterized in terms of deficits in phonological recoding, orthographical decoding, access to word meanings, syntactic and semantic integration, and establishing local and global coherence. We conclude that 'the' dyslexic reader defined by one specific cognitive deficit is a misconception. Instead, the sources and symptoms of reading disability are multifaceted and heterogeneous, and the individual pattern of deficits needs to be considered when planning remediation and intervention programs.

Keywords: aptitude-achievement discrepancy, dyslexia, reading comprehension, reading difficulty, text comprehension

Reading comprehension is one of the preconditions for a successful educational development. Therefore, one of the most important goals of the educational system is the early identification of poor readers and the development of individual intervention and remediation programs to help them overcome their reading difficulties. But, under what conditions is a reader considered to be a poor reader? Usually, poor readers are diagnosed with specific reading disability (developmental dyslexia) when they show below age-average reading comprehension in the absence of any other cognitive deficit and adverse environmental factors (American Psychiatric Association 2013; World Health Organization 2010). Thus, only readers performing substantially worse on standardized reading tests than expected levels based on their general level of cognitive functioning are considered to be dyslexic. To date, this discrepancy model of dyslexia is widely used by educators and researchers to identify poor readers and assign them to specific training and remediation programs.

Despite the widespread use of the discrepancy model, diagnosing a reader as dyslexic provides no information about individual underlying causes of poor reading comprehension nor the kind and the extent of required intervention. Even worse, the operational definition of a separate category of dyslectic readers according to the discrepancy model requires the use of cut-off values that, besides lacking a substantial rationale, exclude poor readers from intervention programs who show a broader range of cognitive disabilities.

In this chapter, we will focus on reading-specific cognitive processes as sources for reading difficulties, excluding such possible sources as working memory, general knowledge, visual, attentional, or neurological deficits (for a review on potential causes of dyslexia that are not specific to reading see Vellutino et al., 2004; Vidyasagar and Pammer 2010). We will first discuss the traditional definition of dyslexia based on the discrepancy model and its problems. We argue that a more fruitful approach to characterize poor readers and their individual needs for

reading intervention would be to examine reading comprehension deficits in a manner that is consistent with the cognitive processes that constitute reading comprehension rather than to simply diagnose a reader as dyslexic or not. Thus, our goal is to provide an overview of the cognitive processes underlying reading comprehension at the word, sentence, and text level and delineate why and how deficits in these processes can contribute to a low level of reading comprehension. We emphasize that identifying the specific origin of reading difficulties is essential to being able to assign poor readers to an appropriate intervention program.

1. Diagnostic criteria of dyslexia and their problems

Estimates of developmental dyslexia prevalence range from 10 to 15%, depending on the exact operational definition (Vellutino et al. 2004). These numbers render dyslexia one of the most prevalent learning disorders. According to the International Classification of Diseases (ICD-10), dyslexic readers manifest "a specific and significant impairment in the development of reading skills that is not solely accounted for by mental age, visual acuity problems, or inadequate schooling" (F81.0, World Health Organization 2010). The term dyslexia is nonexistent in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, APA 2013). Instead, the manual contains a similar definition of Specific Learning Disorder with reading difficulties as the further specification. Thus, dyslexic readers exhibit severe difficulties in the acquisition of basic reading and spelling skills in the absence of a general learning deficit (Rack, Snowling, and Olson 1992; Vellutino et al. 2004). Schools, remediation programs, and researchers following this definition rely primarily on two skill criteria to identify dyslexic readers: Reading skills that are significantly worse than would be expected based on (1) a reader's chronological age and (2) a reader's cognitive abilities or mental age (often operationalized by measures of intelligence). Thus, readers with at least an average IQ

(≥ 80-90; Siegel 1988) who perform unexpectedly poor on reading tasks as compared to their peer's performance are considered dyslexic. These readers are usually distinguished from another group of poor readers called "general backward readers" (Rutter and Yule 1975) or "garden-variety poor readers" (Stanovich 1988) who also fail to acquire age appropriate reading skills, but in contrast to dyslexic readers, they are additionally characterized by a broader range of cognitive deficits accompanied by a low IQ (≤80). This is also known as the aptitude-achievement discrepancy, which indicates that a dyslexics' ability to read (achievement) diverges from their expected levels based on their intellectual capacity (aptitude). The discrepancy model is largely based on the work by Yule et al. (1974) who found considerably more poor readers (a "hump") at the lower end of the reading skill distribution of readers than would have been statistically expected assuming a normal distribution. Yule et al. and Rutter and Yule (1975) assume that a subgroup of the poor readers must be qualitatively different from the normally developing poor readers because of a specific reading deficit. Furthermore, Yule (1973) claimed that the future prospects concerning reading development are significantly worse for dyslexic than for backward readers and conclude that the distinction between these two groups of readers is both meaningful and beneficial for remediation.

These conclusions, however, have been extensively challenged in recent years. Two major arguments against the usefulness of the dyslexia definition in identifying and characterizing poor readers have been advanced. The first and most important objection is that dyslexia, defined as unexpectedly low reading achievement despite normally developing cognitive skills, lacks diagnostic value with respect to the kind of underlying deficit and required intervention. One specific unitary deficit in poor readers is a misconception. Instead, the sources of individual reading deficits are multifaceted and heterogeneous. Several reading-related cognitive component skills may be impaired in poor readers to different degrees. Therefore, each deficit requires a

specific intervention that addresses the specific impaired reading-related process and its degree of severity (Coltheart and Jackson 1998).

The second objection concerns the assumption of a discrete group of dyslexic readers that differ qualitatively from a group of general backward readers. Stanovich (2005), one of the most emphatic opponents of the discrepancy criterion, maintained that the literature lacks evidence showing that dyslexic and general backward readers process reading-related information in a different manner. Siegel (1988) and Stanovich and Siegel (1994) measured the performance of poor readers with high IQ scores on several tasks that tapped cognitive reading-specific skills and compared it with the performance of readers with lower IQ scores. The children in both studies were presented with a battery of reading-related tasks, for example, word and non-word reading, spelling, phonological recoding, grammatical closure, and sentence repetition, and they were also presented with tasks assessing skills that are less specific to reading such as working memory capacity. Both studies consistently indicated that the distinction of good vs. poor readers strongly predicted children's performance on reading-specific tasks, whereas IQ scores (high vs. low) did not (see also Vellutino et al. 2000 and a meta-analysis by Stuebing et al. 2002). Hence, several authors (e.g. Shaywitz et al. 1992; Stanovich 1988) have argued that dyslexic readers represent the lower end of a continuous distribution of readers rather than a discrete category. If readers vary gradually on a continuum of reading ability and if this reading ability is independent of IQ, then setting an arbitrary IQ-based cut-off between dyslexic and general backward readers has no basis. However, despite these findings, the distinction between dyslexic and general backward readers on the basis of IQ scores is still widely used. Consequently, children classified as poor but not dyslexic readers are often excluded from research and interventional programs based on an arbitrary cut-off criterion (Catts et al. 2003; Shaywitz et al. 1992; Stanovich 1988). Instead, as Siegel emphasizes, identify the impaired component processes of reading and the particular form

and extent of the deficit would be far more helpful, including determining the appropriate strategy for enhancing the deficient processes (see also Catts et al. 2003).

In view of these findings, we argue for a cognitive-psychological approach to reading comprehension difficulties. Rather than defining a group of dyslexics on the basis of questionable criteria, a more fruitful approach would be to examine the reading difficulties in terms of the underlying cognitive processes and to determine the extent to which component processes are impaired and the appropriate strategy for improving the mastery of these processes. The aim of the following sections is to provide an overview of the possible sources of difficulties in reading comprehension based on the structure of reading comprehension cognitive-component skills. Diagnostic tools designed to identify individual needs for training and intervention in poor readers must be conceived according to this underlying structure.

2. What causes poor reading comprehension?

Cognitive-psychological research on reading comprehension has identified a number of cognitive processes at the word, sentence, and text level that contribute to reading comprehension (Müller and Richter 2014; Perfetti 2001; Richter and Christmann 2009). First, readers must recognize the written word forms of a text. According to dual-route models of visual word recognition, readers accomplish this task via two different routes (Coltheart et al. 2001). To be able to recognize unknown or infrequent word forms, readers use a *non-lexical*, rule-based phonological route by translating the word letter-by-letter into a phonemic representation (phonological recoding). The phonemic representation is subsequently mapped on to an entry in the mental lexicon. When processing familiar and highly frequent word forms, readers use an orthographic or *lexical* route by which word forms are recognized holistically and mapped directly on to an entry in the mental lexicon (for evidence supporting the dual route cascaded

model of visual word recognition—DRC, see e.g. Paap and Noel 1991; Ziegler, Perry, and Coltheart 2000). After successfully recognizing a word form, readers need to retrieve its meaning from the mental lexicon. At the sentence level, they must integrate the word forms syntactically and semantically. Finally, in text and discourse comprehension, several sentences need to be integrated into a coherent mental model of the text by establishing local and global coherence relations between adjacent and distant sentences (McNamara and Magliano 2009; Van Dijk and Kintsch 1983). This multi-level structure of component skills implies that reading comprehension succeeds to the extent that readers master all of the cognitive processes involved in reading efficiently. Individual differences in these processes are potential sources of individual differences in reading comprehension skills. Hence, deficits in the mastery of these processes potentially cause specific types of reading difficulties.

2.2 Individual differences at the word level

The majority of studies investigating possible causes of poor reading comprehension have focused on word-level processes. This method seems to be a reasonable starting point, because the ability to recognize written word forms is clearly crucial for reading comprehension. The importance of word-level processes for individual differences in reading comprehension is expressed very clearly in the *simple view of reading* (*SVR*, Gough and Tunmer 1986; Hoover and Gough 1990), which assumes reading comprehension (*R*) to be the product of two types of cognitive abilities, the general ability to comprehend language (*C*) and the ability to decode written word forms (*D*):

$$R = D \times C$$

The multiplicative combination of *D* and *C* implies that good decoding skills and good general comprehension skills are each necessary but not sufficient to bring about good reading

comprehension. Instead, reading comprehension is impaired when only one of the two abilities is low. According to the simple view of reading, decoding is the only process that distinguishes reading from listening comprehension. Consequently, visual word recognition is a prominent candidate when looking for possible sources of reading difficulties.

Another general theoretical approach that emphasizes the role of word recognition processes in reading comprehension is Perfetti's (1985) *verbal efficiency hypothesis*, which states that efficient word recognition constitutes the fundament of successful reading comprehension. The underlying idea is that efficient (i.e. rapid and reliable) word-recognition processes save cognitive resources, which are then available for higher cognitive processing, such as sentence and text level processing. The verbal efficiency hypothesis was further refined into the *lexical quality hypothesis* by Perfetti and Hart (2001, 2002; see also Perfetti 2010), which emphasizes that the quality of the representations of word forms, including the stability and interconnectedness of their constituents (phonological, orthographic, morphological, and semantic components), is the basis for good reading comprehension.

2.2.1 Individual differences in phonological recoding

Most explanatory approaches of dyslexia and of poor reading comprehension in beginning readers agree that a likely source of reading disability is a deficit in phonological recoding. This idea is appealing from a developmental point of view. Phonological recoding skills are the key to the acquisition of reading skills, because word forms are still unknown to beginning readers and need to be recoded letter-by-letter (Coltheart et al. 2001; see also the developmental model by Frith 1985). As a consequence, deficient phonological recoding hinders the child to read the majority of written word forms and impairs all further stages of reading development. Deficits in phonological recoding may be caused by deficits in general phonological processing. Stanovich

(1988) and Stanovich and Siegel (1994) compared the performance of poor and skilled readers on several tasks accessing phonological skills in written and auditory modality. They found that all poor readers, in contrast to skilled readers, exhibited severe problems with tasks, such as regular and exception word naming, non-word naming, and rhyme production. Based on his findings, Stanovich (1988) created the *phonological-core variable-differences model*, which states that poor readers primarily suffer from a deficit in phonological processing skills that prevents them from the acquisition of age-appropriate reading abilities. Evidence in favor of this assumption comes from various sources. For example, Snowling (1980) found that poor dyslexic readers, in contrast to skilled readers, had difficulties recognizing an auditorily presented word in its written form and exhibited the same difficulties in the reverse order. Because this task required grapheme-phoneme-conversion in both directions, Snowling concluded that the poor readers had difficulties in mapping sounds on letters and letters on sounds. Griffith and Snowling (2001) investigated whether the phonological deficit of poor readers is due to deficient phonological representations or to a deficit in retrieving the phonological information. They found that 11- to 12-year-old poor readers with the diagnosis of dyslexia performed worse than good readers of the same age in rapid-naming and non-word reading tasks that required the retrieval of phonological information. However, in an auditory word-gating task, no differences were found between good and poor readers on amount of phonetic input they needed to identify a spoken word. This finding indicates that the deficit of poor readers can be due to deficient retrieval processes rather than deficient phonological representations. This interpretation was further supported by more recent studies by Ramus et al. (2013) and Dickie et al. (2013). Their results indicate that phonological deficits in poor readers are not due to deficient phonological representations but rather to poor skills in assessing or manipulating them. However, using a similar word-gating paradigm to the one used by Griffith and Snowling (2001), Boada and Pennington (2006) found

evidence for deficient implicit phonological representations in poor readers rather than deficient phonological retrieval processes. In contrast to the findings by Griffith and Snowling, the poor readers in the study by Boada and Pennington needed more phonetic input to correctly recognize the first letter in a word than the chronological age-control group and more phonetic input to correctly recognize the whole word than the chronological age-control group and the reading age-control group. The authors concluded that poor readers have more "immature phonological representations" (2006: 177) than their age and reading peers.

A number of longitudinal and training studies provided evidence to support the assumption of a causal relationship between phonological deficits and poor reading abilities (Rack et al. 1992; Vellutino et al. 2004). These studies demonstrated that children's phonological skills in kindergarten predict reading comprehension in primary school (e.g. Bradley and Bryant 1983; Scanlon and Vellutino 1996). Moreover, interventions strengthening the phonological awareness in kindergarten and at the beginning of primary school were shown to have a positive impact on later reading comprehension skills (e.g. Bradley & Bryant 1983; for a meta-analysis, see Bus and van Ijzendoorn 1999). Some studies suggest that phonological deficits persist even in adults with childhood diagnosis of dyslexia (e.g. Wilson & Lesaux 2001; Ransby and Swanson 2003). However, Castles and Coltheart (2004) emphasized that extant studies providing evidence in favor of a causal relationship between phonological skills and reading skills should be interpreted with caution. They criticized that most of these studies merely show a correlational relationship rather than a causal one and are circular in their argumentation. They also claimed that most longitudinal and training studies fail to meet the necessary criteria to unequivocally ascribe success in reading acquisition to good phonological awareness skills or to phonological awareness trainings. They stated that in terms of a causal relationship, for example, phonological awareness trainings should improve reading skills specifically, i.e. "only reading-related skills"

(2004: 76) should benefit from the training. Another claim is that there must be no letter-sound knowledge at all prior to phonological awareness training to not confound training effects with "implicit reinforcement of pre-existing reading skills" (2004: 99). Given that most studies fail to meet these and other critical criteria, Castles and Coltheart concluded that the causal relationship between phonological skills and reading performance still needs to be replicated in future research. However, Hulme et al. (2005) criticized Castles and Coltheart's (2004) "conception of causation [as] overly narrow" (2005: 360). They argued that effects of phonological skills on reading development might be moderated or mediated by other reading-related skills such as letter-sound knowledge, but these influences do not preclude the importance of phonological skills in reading acquisition and development.

Remarkably, the close relationships of phonological deficits and poor reading comprehension are cross-linguistically evident in poor readers of languages other than English. Wimmer (1996) and Ziegler et al. (2003) found that 9- to 13-year-old dyslexic readers in German completed non-word reading tasks as slowly as English dyslexic readers (and more slowly compared to word reading tasks). However, German dyslexic readers performed with notably higher accuracy on non-word reading tasks compared to English dyslexic readers of the same age. The authors attribute the higher accuracy of German dyslexic readers to the transparent orthography of German. The grapheme-phoneme-conversion rules are highly consistent in the German language. Thus, phonological recoding is much easier in German compared to languages with an opaque orthography such as English and is therefore acquired earlier (Wimmer and Goswami 1994). As a result, even dyslexic readers in German have little difficulties reading non-words accurately, but they lack the necessary automaticity to read non-words with little cognitive effort as indicated by long reading times. Wimmer concluded that the deficit underlying poor

reading performance is a phonological deficit in both languages (see also Mayringer and Wimmer 2000), but this deficit is somewhat differently expressed in German than in English poor readers.

A possible objection concerning the generalizability of previous findings is that many investigations concentrated on beginning readers. Beginning readers are bound to rely primarily on the non-lexical phonological recoding route when recognizing words, because most written word forms are unknown for them. Hence, for beginning readers, most of the variance in reading comprehension skills is not surprisingly explained by phonological recoding skills. However, more experienced readers increasingly make use of the more efficient (lexical) route of orthographical decoding, depending on the size, quality, and accessibility of their sight vocabulary (Frith 1985). Thus, orthographical decoding skills during the primary school years become an increasingly important source of individual differences in reading comprehension (although phonological recoding skills remain a strong and unique predictor even in Grade 4, Knoepke et al. 2014).

2.2.2 Individual differences in orthographical decoding

Several studies suggest that a deficit in orthographical decoding, also called surface dyslexia, can cause severe reading comprehension problems as well. Castles and Coltheart (1993) disentangled both types of word recognition deficits using non-word and exception-word reading. Because phonological recoding skills are required for non-word reading and orthographical decoding skills are required for exception-word reading, poor readers with a phonological deficit should exhibit difficulties reading non-words but less difficulties reading exception words. In contrast, poor readers with a deficient orthographical decoding route should exhibit difficulties reading exception words but fewer difficulties reading non-words. This pattern of double dissociation was obtained in several studies. In one study, Castles and Coltheart (1993, Exp. 1)

investigated 8- to 14-year-old dyslexic readers' performance on non-word and exception-word reading tasks and found that 85% of the dyslexic readers showed the expected double dissociation. Either their non-word reading skills were significantly poorer than their expected exception-word reading performance (55%) or their exception-word reading performance was significantly poorer than their expected non-word reading performance (30%). Thirty four percent of the dyslexic readers even performed poorly on just one of the tasks, whereas they exhibited no difficulties at all with the other task. In their second study (Exp. 2), Castles and Coltheart found that readers performing poorly on exception-word reading had no problems comprehending spoken exception words, ruling out an alternative explanation in terms of general language deficits (similar results were obtained by Manis et al. 1996).

Some evidence exists showing that the prevalence of the two types of deficits depends on language-specific differences. As noted earlier, several studies suggested that dyslexic readers' phonological recoding is slow but reliable in transparent orthographies such as German, in contrast to opaque orthographies such as English (e.g. Mayringer and Wimmer 2000; Wimmer 1996; Ziegler et al. 2003). Complementing these findings, more recent studies indicated that dyslexic readers' orthographical decoding route is more likely to be deficient in transparent orthographies (e.g. Martens and de Jong 2006; Zoccolotti et al. 2005). The *word-length effect* has been used to investigate this deficit. When recognizing words via the non-lexical, phonological recoding route, i.e. by means of grapheme-to-phoneme-conversion, the length of written-word forms is positively related to the time it takes to recognize the word. However, when words are recognized via the orthographical decoding route, whole-word forms are directly mapped on to their respective lexical entries, and word length has no impact on word recognition times. In a word-naming study based on this logic, Zoccolotti et al. (2005) found that skilled Italian readers' sensitivity to word length decreased from Grade 1 to Grade 2, suggesting a shift from

phonological recoding to orthographical decoding. In contrast, dyslexic third graders were as sensitive to word length during word and non-word naming as first graders indicating that they still primarily relied on phonological recoding. Similar results were obtained in Dutch by Martens and de Jong (2006) and in German by Ziegler et al. (2003; for additional evidence suggesting a strong relationship between orthographical decoding skills and text comprehension in German primary school children, see Knoepke et al. 2014).

These findings clearly indicate that conceptualizing dyslexia as a purely phonological deficit fails to explain the variety of poor readers. At least two types of word recognition deficits exist, a more phonologically-based and a more orthographically-based deficit that can underlie reading comprehension problems (e.g. Castles and Coltheart 1993; Manis et al. 1996). This distinction has implications for remediation and intervention programs. The assumption that phonological or grapheme-phoneme-conversion trainings suggested by phonological-core deficit models of dyslexia would work equally well for all poor readers is unreasonable. Instead, testing poor readers on a broader range of word-recognition skills is essential to determine their specific training needs.

Dual-route models make important contributions to the description and explanation of visual word recognition processes, their acquisition and development, various types of word recognition deficits, and language-specific differences with respect to opacity and transparency, but other theoretical approaches of visual word recognition also exist that reject the idea of two functionally distinct routes. Instead they model word recognition in a single information-processing network as in, for example, the *parallel-distributed-processing* (PDP) model (Seidenberg and McClelland 1989) or the *connectionist triangle model* (Plaut et al. 1996). These models explain and predict the various types of deficits in visual word recognition by impaired distributed representations or “computational resource limitations” (e.g. Manis et al. 1996: 189),

by impaired network pathways (e.g. Plaut 1999), or by impairment of neurological areas involved in the network responsible for reading (e.g. Woollams 2014). In many cases, these models make similar predictions as dual route models. Thus, deciding among these different approaches is difficult based on the available evidence.

The reader should note that dual-route models of visual word recognition have been developed to explain reading acquisition, development, and disorders in Indo-European languages with alphabetic scripts such as German, English, and Spanish. Consequently, this approach could fail to fully explain the relationships between visual word recognition and reading comprehension skills in languages with non-alphabetic scripts such as Chinese and Japanese (for a more detailed discussion, see e.g. Frost 2012).

2.2.3 Individual differences in the quality of and access to meaning representations

The retrieval of word meanings is an additional word-level source of reading comprehension problems. The retrieval of word meanings is the basis of text comprehension, suggesting that individual differences in the mastery of this process are a proximal predictor of reading comprehension problems (Richter et al. 2013). According to Perfetti and Hart's *lexical quality hypothesis* (2001, 2002; Perfetti 2007), lexical representations comprise not only formal properties of words (such as the word's phonology or orthography) but also meaning representations. Moreover, the overall quality of a lexical representation depends on the qualities of these components and their interconnectedness. If one of them is not (fully) specified, the lexical representation is lower in quality. A substantial amount of low-quality lexical representations will hamper reading comprehension (Perfetti and Hart 2001, 2002).

In a study with adult readers of varying reading comprehension skills, Perfetti and Hart (2001) demonstrated that the skilled and poor readers differed in the quality of their meaning

representations. The participants were presented with written word pairs such as *king – royalty* (2001: 76) and were required to decide whether the words were semantically related. The word pairs appeared word-by-word with differing inter-stimulus intervals and contained either a homophone, such as *night* in *night – royalty* (2001: 76), or no homophone. The authors expected skilled readers to make faster decisions and to show an earlier interference effect for homophones compared to poor readers. They reasoned that skilled readers have faster access to word meanings because of their superior meaning representations. In line with this assumption, they observed faster decision times and earlier interference effects in the presence of homophones for skilled compared to poor readers.

In a cross-sectional study with primary school children from Grade 1 to 4, Richter et al. (2013) directly tested the assumption that the quality of meaning representations is a proximal predictor of reading comprehension at the text level. The children were presented with tasks accessing the quality of their phonological representations (phonological comparison task), their orthographical representations (lexical decision task), and their meaning representation (semantic verification task), as well as their reading comprehension skills at the text level (ELFE 1-6, Lenhard and Schneider 2006). The results indicate that the overall quality of the children's lexical representations and the efficiency of access to these representations explained a substantial amount of variance in their reading skills. Moreover, the effect of the quality of phonological and orthographical representations on reading comprehension was found to be mediated by the quality of meaning representations. Notably, individual differences in the quality of meaning representations accounted for a substantial amount of variance in reading comprehension that could not be explained by variance in word recognition skills (Richter et al. 2013). A study by Nation and Snowling (1998) suggests a similar conclusion by showing that semantic deficits can

explain word recognition and reading comprehension problems in poor readers with normal phonological recoding skills.

Nation and Snowling (1999) used a priming paradigm to demonstrate qualitative differences in the abstract semantic knowledge of children classified as good vs. poor readers. In a priming experiment, the good readers made faster lexical decisions on target words (e.g. *cat*) when a prime of the same category (*dog*, 1999: B1) preceded the target word than when they were preceded by an unrelated word. However, poor readers' responses were primed by preceding category members only when prime and target words were highly associated. In contrast, both good and poor readers showed comparable priming effects when prime and target words were functionally related (e.g. *shampoo – hair*, 1999: B1). The authors assumed that the poor readers primarily possessed an event-based semantic word knowledge, whereas the better readers had already built abstract semantic representations.

In sum, a number of studies using different methods and focusing on different age groups indicate that a low quality and accessibility of word-meaning representations can cause reading comprehension problems in addition to the deteriorating effects of deficits in phonological recoding and orthographic decoding.

2.3 Individual differences beyond the word level

The explanatory approaches of poor reading comprehension skills discussed in the previous sections attribute poor reading abilities primarily to word-level skills. Word-level processes are clearly a major source of reading comprehension difficulties, but the existence of readers who show poor reading comprehension despite adequate word reading skills suggests that cognitive processes must be considered in addition to the word-level to better understand reading comprehension difficulties (e.g. Cain et al. 2001; Nation and Snowling 1998, Exp. 2, 1999;

Stothard and Hulme 1992). Several studies have demonstrated, in accordance with the simple view of reading, that a substantial amount of variance in reading comprehension can be explained by individual differences in general language (listening) comprehension (Catts et al. 2003; Johnston and Kirby 2006; Joshi and Aaron 2000; Kendeou et al. 2009; Knoepke et al. 2013; Ransby and Swanson 2003). These language comprehension skills comprise several component skills at the sentence and text level. In the following section, we will discuss studies that examined the potential impact of some of these component skills on reading comprehension problems. The studies included children with adequate word recognition but impaired comprehension skills or they controlled for word recognition skills statistically to investigate the unique contribution of sentence- and text-level skills to individual differences in reading comprehension.

2.3.1 Individual differences in syntactic and semantic integration processes

To comprehend a sentence, simply decoding the words of the sentence and retrieving their meanings is not sufficient. The reader must integrate the individual word meanings into a coherent mental representation of the sentence according to its specific syntactic and semantic structure (e.g. Müller and Richter 2014; Richter and Christmann 2009). For example, the sentence *Katie sues Robert* contains exactly the same words as the sentence, *Robert sues Katie*. Based on the word meanings alone, a reader can determine the prosecutor and the respondent in the sentence. However, the syntactic structure of transitive English main clauses (subject-verb-object) reveals that in the first sentence *Katie* is the prosecutor and in the second sentence she is the respondent. In addition to the syntactic structure, a reader can also use the semantic context of a sentence to resolve, for example, syntactic or semantic ambiguities. In the sentence, *the bug has*

been killed/removed, the interpretation of *bug* as either an insect or a technical error depends entirely on the semantic context of the sentence (insect: *killed;* technical error: *removed*).

Ample evidence exists showing a relationship between individual differences in syntactic and semantic integration processes and reading comprehension. For example, poor syntactic awareness, i.e. a reader's "ability to reflect upon and to manipulate aspects of the internal grammatical structure of sentences" (Tunmer et al. 1987: 25) and deficient processes of semantic integration can result in reading difficulties in some poor readers. Byrne (1981) found a positive relationship between syntactic awareness and reading comprehension in poor vs. good beginning readers. In an act-out-task, the children were presented with spoken sentences, which were the same length but differed in grammatical structure complexity. In addition, children worked on a picture-choice task with spoken sentences varying in plausibility containing center-embedded relative clauses. Pictures matching plausible sentences were easy to find with the aid of the semantic context of the sentence, but pictures matching less plausible sentences required the aid of syntactic knowledge for their correct identification. The poor readers' performance on the syntactically more complex sentences in the act-out task and on the less plausible sentences in the picture-choice-task was inferior to the good readers' performance on these sentences. In contrast, the between-group performances were comparable for the less complex and plausible sentences. Similarly, Tunmer et al. (1987) found that older poor readers were less able to correct spoken sentences containing morphological or word-order violations or to supply a missing word in an auditory presented sentence compared to younger skilled readers of the same reading level. Poor readers also seem to have difficulties restructuring the words of a scrambled sentence back into their correct order (Nation and Snowling 2000) and to perform poorly on Bishop's (1983) test for the reception of grammar (TROG; Stothard and Hulme 1992). In a longitudinal study with French children from Kindergarten to Grade 2, Casalis and Louis-Alexandre (2000) found that

morpho-syntactic skills in Kindergarten, such as the ability to inflect nouns for gender or verbs for tense form, are predictive of sentence comprehension at the end of Grade 2. Plaza and Cohen (2003) demonstrated that syntactic awareness operationalized by a grammatical judgment and correction task was predictive of reading and spelling skills in French primary school children at the end of Grade 1. Moreover, syntactic awareness accounted for unique variance in reading and spelling even when phonological awareness, naming speed, and auditory memory were statically controlled. These studies suggest that individual differences in syntactic awareness and syntactic integration skills explain unique variance in reading comprehension and that deficient syntactic skills might cause reading difficulties.

In a reading time study with adult readers, Graesser et al. (1980) found that the syntactic complexity and the semantic complexity of sentences (independent from each other) had a greater retarding impact on slow readers compared to fast readers. Considering that the slower readers are likely to have lower reading skills, this finding suggests that poor readers need to invest a greater amount of cognitive resources to comprehend syntactically and semantically complex sentences. Investigating semantic integration skills, Hannon and Daneman (2004) found that less skilled readers tend to invest less cognitive effort in the establishment of coherence relations within a sentence in favor of establishing more global coherence relations. They presented poor and skilled readers with short texts containing a semantic anomalous term in the final sentence of the text, such as *Amanda was bouncing all over because of too many tranquilizers/ sedatives/ tranquilizing sedatives/ tranquilizing stimulants* (2004: 197). Poor readers were less likely to detect anomalies than skilled readers and they were less likely in particular to detect anomalies in internally incoherent noun phrases (e.g. *tranquilizing stimulants*) compared to internally coherent noun phrases (e.g. *tranquilizing sedatives*), indicating a rather shallow semantic processing of the meaning of noun phrases and sentences in poor readers.

Semantic information, in particular the semantic context of a sentence, can also be beneficial for poor readers with deficits in word-level processes, because the context helps these readers to recognize the words and infer their meaning. This explanation is the basic assumption of the *interactive-compensatory model* proposed by Stanovich (1980). The model is based on evidence from a number of inventive experiments that compared the word-recognition performance of good vs. poor readers under different contextual manipulations (see also West and Stanovich 1978). These experiments consistently revealed that the performance of the poor readers depended more heavily on the presence of a facilitating sentence context, whereas the good readers relied on their superior word-recognition skills rather than the sentence context. In a similar vein, Gernsbacher and Faust (1991, Exp. 4) demonstrated that poor readers extensively use a restricting semantic context when it facilitates word recognition (for similar results for dyslexic readers, see Nation and Snowling 1998, Exp. 2). Van der Schoot et al. (2009) found in an eye-tracking (Exp. 1) and in a self-paced reading study (Exp. 2) that poor 10- to 12-year-old Dutch readers used prior contextual information as effectively as skilled readers to resolve lexical ambiguities. However, in contrast to skilled readers, poor readers were less likely to correct an initial incorrect interpretation of an ambiguous word, indicating less efficient comprehension monitoring in poor readers.

Importantly, Gernsbacher and Faust (1991, Exp. 1) showed that poor readers have difficulties to suppress context-inappropriate meanings. The task was to judge the semantic relatedness of a sentence and a word that was presented after the final word of the sentence (e.g., *He had a lot of patients*). Poor readers showed a substantial and long-lasting interference effect in rejecting a probe word (*CALM*) when it did not fit the sentence but was semantically related to a homophone of the final word (*patience*). In contrast, good readers exhibited this interference effect only when the probe word was presented immediately after the sentence. These results

suggest an effective and rapid suppression of inappropriate word meanings by good but not poor readers.

In sum, the findings of the reported studies suggest that efficient syntactic and semantic integration processes are an important prerequisite for good text comprehension. If these processes are ineffective or deficient, the overall reading ability may be adversely affected.

2.3.2 Individual differences in inference making and comprehension monitoring

Text comprehension goes beyond the sentence level by requiring the integration of information provided by several sentences into a coherent mental representation. According to Johnson-Laird (1981) and Van Dijk and Kintsch (1983), this mental representation consists of two qualitatively distinct levels. Readers need to construct a coherent representation of the semantic structure of the text (*propositional text base*), and they need to integrate text information and prior knowledge to build a *mental model* (Johnson-Laird 1981) or *situation model* (Van Dijk and Kintsch 1983) of the circumstances described in a text. Thus, constructing a situation model (mental model) is essential for comprehending the text, and it requires several closely related cognitive activities, such as linking the contents of adjacent and distant sentences (Singer et al. 1992), using prior knowledge for drawing inferences (Graesser et al. 1994), predicting upcoming text (Van Berkum et al. 2005), monitoring the plausibility of the text content (Isberner and Richter 2013), and monitoring the comprehension process (Nation 2005). The key question is whether individual differences in these processes explain unique variance in overall reading comprehension in addition to readers' word recognition skills. In a longitudinal study, Oakhill et al. (2003) and Cain et al. (2004) focused on the unique contribution of inference skills and individual differences in comprehension monitoring to reading comprehension. Inference skills can be defined as the ability to derive information from the text context and from

world knowledge to enrich the mental representation of the text. Comprehension monitoring skills can be defined as the metacognitive ability to monitor the comprehension process and to detect comprehension problems as well as inconsistencies with the text or with prior knowledge (Baker 1989). Oakhill et al. (2003) and Cain et al. (2004) presented children with several tasks that assessed inference-making skills, comprehension monitoring skills, verbal ability, working memory skills, and overall text comprehension. The ability to draw inferences and to monitor their comprehension process explained unique variance in reading comprehension even when verbal ability and single word recognition abilities were statistically controlled. These relationships were found in beginning readers aged 7 to 8 years (Oakhill et al. 2003) and also in older readers until the age of 11 (Cain et al. 2004). Although a substantial amount of variance in reading comprehension was explained by working memory capacity, this general cognitive ability failed to fully explain the effects of inference making and comprehension monitoring on reading comprehension. Instead, both higher-order cognitive component skills of text comprehension accounted for a unique portion of variance in children's reading comprehension. In accordance with these findings, Van der Schoot, Vasbinder, Horsley, Reijntjes, and Van Lieshout (2009) demonstrated that poor readers were less able to monitor their comprehension process than skilled readers. In contrast to good comprehenders, poor readers' reading times on disambiguating information that followed a lexically ambiguous word were the same as when the information preceded the word. Moreover, they made more errors responding to comprehension questions when a lexically ambiguous word with a biased (not intended) meaning preceded the disambiguating region. The authors concluded that the poor readers are less likely to detect an interpretation error (as indicated by the lack of reading time increase on the disambiguating information) and to repair it (indicated by lower response accuracy).

The impact of inference skills on text comprehension has received ample attention in

research. Bridging inferences that connect two pieces of information in a text, such as anaphoric (e.g. Garnham and Oakhill 1985) and causal inferences (e.g. Singer et al. 1992), are especially important for constructing a coherent situation model. Cain and Oakhill (1999) and Cain et al. (2001) focused on individual differences in such text-connecting inferences and elaborative or gap-filling inferences, which refer to processes of "incorporating information outside of the text, i.e. general knowledge, with information in the text to fill in missing details" (Cain et al. 2001: 490). Seven- to 8-year-old children read short text passages and answered questions requiring the identification of literal assertions in the text, making text-connecting and gap-filling inferences. Cain and Oakhill (1999) found that poor readers drew fewer inferences of both types than good readers, whereas both groups performed equally well on literal assertions. To rule out the possibility that the poor readers' inferior performance on the inference questions was due to a lack of necessary background knowledge, Cain et al. (2001) replicated the findings holding background knowledge constant. In this study, they provided children with background knowledge about a fictional planet named *Gan* to ensure that all children had the same background. As in the Cain and Oakhill study, the poor readers had significantly more difficulties drawing text-connecting and gap-filling inferences than the good readers. Moreover, poor readers' performance on the inference questions could not be attributed to a lack of background knowledge.

These findings consistently suggest that word-level and text-level skills independently contribute to text comprehension variance. Oakhill et al. (2003) emphasized that determining the exact causes of reading difficulties and considering this individual pattern of deficits when planning remediation and intervention programs for poor readers is essential. Ideally, educators should take care to tailor such programs as accurately as possible to the needs and deficits of the individual reader. To accomplish this, the gross screening instruments that are typically used for

diagnosing reading difficulties need to be augmented with more discriminative psychological tests that assess component skills of reading comprehension. One promising way to assess these skills is to measure the efficiency of the specific component processes of reading comprehension by using reaction-time measures in combination with well-defined reading tasks and test items that are constructed according to (psycho-)linguistic criteria (for an example, see the German-speaking test battery ProDi-L, Richter et al. in press).

3. Conclusion

This chapter discussed several problems concerning the common definition of dyslexia and its diagnostic value in identifying poor readers and their individual needs for training and intervention. In particular, we emphasized that the diagnosis of dyslexia bears no information about the cause of the individual reading deficit or the kind and extent of intervention that is required. Furthermore, we argued that the distinction between dyslexic and general backward readers based on the wide-spread discrepancy model of dyslexia is not empirically useful. One argument against the discrepancy model is that poor readers classified as dyslexic according to the discrepancy model perform the same on reading-related tasks as poor readers with a more general cognitive deficit. Consequently, both groups receive the same reading intervention. In that respect, a cognitive perspective on reading difficulties that examines component processes of reading at the word-, the sentence-, and the text level is far more promising. Even readers in the same age group differ greatly in the extent that they accurately and efficiently master these cognitive processes at all three levels. We argued that individual differences in word-, sentence- and text-level processes contribute uniquely to individual differences in reading comprehension. Against this background, we conclude that the potential causes for reading difficulties are multifaceted and heterogeneous. One important practical implication of this conclusion is that the

success of intervention and remediation programs depends heavily on the identification of the specific type of cognitive deficit that causes reading difficulties in the poor reader.

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References

American Psychiatric Association. 2013. *Diagnostic and statistical manual of mental disorders, 5th edn. (DSM-V)*. Washington, DC: American Psychiatric Publications.

Baker, Linda. 1989. Metacognition, comprehension monitoring and the adult reader. *Educational Psychology Review* 1(1). 3-38.

Boada, Richard & Bruce F. Pennington. 2006. Deficient implicit phonological representations in children with dyslexia. *Journal of Experimental Child Psychology* 95(3). 153-193.

Bishop, Dorothy V. M. 1983. The test for reception of grammar. Manchester: University of Manchester.

Bradley, Lynette & Peter E. Bryant.1983. Categorizing sounds and learning to read: A causal connection. *Nature* 301(5899). 419-421.

Bus, Adriana G. & Marinus H. van IJzendoorn. 1999. Phonological awareness and early reading: A meta-analysis of experimental training studies. *Journal of Educational Psychology* 91(3). 403-414.

Byrne, Brian. 1981. Deficient syntactic control in poor readers: Is a weak phonetic memory code responsible? *Applied Psycholinguistics* 2(3). 201-212.

Cain, Kate & Jane V. Oakhill. 1999. Inference making ability and its relation to comprehension failure in young children. *Reading and Writing: An Interdisciplinary Journal* 11(5-6). 489-503.

Cain, Kate, Jane V. Oakhill, Marcia A. Barnes & Peter E. Bryant. 2001. Comprehension skill, inference-making ability, and their relation to knowledge. *Memory & Cognition* 29(6). 850-859.

Cain, Kate, Jane V. Oakhill & Peter E. Bryant. 2004. Children's reading comprehension ability: Concurrent predictions by working memory, verbal ability, and components skills. *Journal*

of Educational Psychology 96(1). 31-42.

Casalis, Séverine & Marie-France Louis-Alexandre. 2000. Morphological analysis, phonological analysis and learning to read French: a longitudinal study. *Reading and Writing*, 12(3). 303-335.

Castles, Anne & Max Coltheart. 1993. Varieties of developmental dyslexia. *Cognition* 47(2). 149-180.

Castles, Anne & Max Coltheart. 2004. Is there a causal link from phonological awareness to success in learning to read? *Cognition* 91(1). 77-111.

Catts, Hugh W., Tiffany Hogan & Marc E. Fey. 2003. Subgrouping poor readers on the basis of individual differences in reading-related abilities. *Journal of Learning Disabilities* 36(2). 151-164.

Coltheart, Max & Nancy E. Jackson. 1998. Defining dyslexia. *Child Psychology & Psychiatry Review* 3(1). 12-16.

Coltheart, Max, Kathleen Rastle, Conrad Perry, Robyn Langdon & Johannes Ziegler. 2001. DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review* 108(1). 204-256.

Dickie, Catherine, Mitsuhiko Ota & Ann Clark. 2013. Revisiting the phonological deficit in dyslexia: Are implicit nonorthographic representations impaired? *Applied Psycholinguistics* 34(4). 649–672.

Frith, Uta. 1985. Beneath the surface of developmental dyslexia. In Karalyn Patterson, John C. Marshall & Max Coltheart (eds.), *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading,* 301-330. London: Erlbaum.

Frost, Ram. 2012. Towards a universal model of reading. *Behavioral and Brain Sciences*, 35(5). 263-329.

Gernsbacher, Morton A. & Mark E. Faust. 1991. The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 17(2). 245-262.

Gough, Philip B.,& William E. Tunmer. 1986. Decoding, reading, and reading disability. *Remedial and Special Education* 7(1). 6–10.

Garnham, Alan & Jane V. Oakhill. 1985. On-line resolution of anaphoric pronouns: Effects of inference making and verb semantics. *British Journal of Psychology* 76(3). 385-393.

Graesser, Arthur C., Nicholas L. Hoffman & Leslie F. Clark. 1980. Structural components of reading time. *Journal of Verbal Learning and Verbal Behavior* 19(2). 135-151.

Graesser, Arthur C., Murray Singer & Tom Trabasso. 1994. Constructing inferences during narrative text comprehension. *Psychological Review 101(3)*. 371-395.

Griffiths, Yvonne M. & Margaret J. Snowling. 2001. Auditory word identification and phonological skills in dyslexic and average readers. *Applied Psycholinguistics* 22(3). 419-439.

Hannon, Brenda & Meredyth Daneman. 2004. Shallow semantic processing of text: An individual-differences account. *Discourse Processes* 37(3). 187-204.

Hoover, Wesley A. & Philip B. Gough. 1990. The simple view of reading. *Reading and Writing: An Interdisciplinary Journal* 2(2). 127-160.

Hulme, Charles, Margaret Snowling, Marketa Caravolas & Julia Carroll .2005. Phonological skills are (probably) one cause of success in learning to read: A comment on Castles and Coltheart. *Scientific Studies of Reading* 9(4). 351–365.

Johnson-Laird, Philip N. 1981. Comprehension as the construction of mental models. *Philosophical Transactions of the Royal Society, Series B* 295(1077). 353-374.

Johnston, Timothy C. & John R. Kirby. 2006. The contribution of naming speed to the simple

view of reading. *Reading and Writing* 19(4). 339-361.

Joshi, R. Malatesha & P. G. Aaron. 2000. The component model of reading: Simple view of reading made a little more complex. *Reading Psychology* 21(2). 85-97.

Kendeou, Panayiota, Robert Savage & Paul van den Broek. 2009. Revisiting the simple view of reading. *British Journal of Educational Psychology* 79(2). 353-370.

Knoepke, Julia, Tobias Richter, Maj-Britt Isberner, Johannes Naumann & Yvonne Neeb. 2014. Phonological recoding, orthographic decoding, and comprehension skills during reading acquisition. *Zeitschrift für Erziehungswissenschaft* 17(3). 447-471.

Knoepke, Julia, Tobias Richter, Maj-Britt Isberner, Yvonne Neeb & Johannes Naumann. 2013. Leseverstehen = Hörverstehen X Dekodieren? Ein stringenter Test der Simple View of Reading bei deutschsprachigen Grundschulkindern [Reading comprehension = listening comprehension X decoding? A stringent test of the simple view of reading in German primary school children]. In Angelika Redder & Sabine Weinert (eds.), *Sprachförderung und Sprachdiagnostik: Interdisziplinäre Perspektiven*, 256-276. Münster, Germany: Waxmann.

Lenhard, Wolfgang & Wolfgang Schneider. 2005. *ELFE 1-6: Ein Leseverständnistest für Erst- bis Sechstklässler* [ELFE 1-6: A reading comprehension test for grades one to six]. Göttingen, Germany: Hogrefe.

Manis, Franklin R., Mark S. Seidenberg, Lisa M. Doi, Catherine McBride-Chang & Alan Petersen. 1996. On the bases of two subtypes of developmental dyslexia. *Cognition* 58(2). 157-195.

Martens, Vanessa E. G. & Peter F. de Jong. (2006). The effect of word length on lexical decision in dyslexic and normal reading children. *Brain and Language* 98(2). 140-149.

Mayringer, Heinz & Heinz Wimmer. 2000. Pseudoname learning by German-speaking children

with dyslexia: Evidence for a phonological learning deficit. *Journal of Experimental Child Psychology* 75(2). 116-133.

McNamara, Danielle S. & Joseph P. Magliano. 2009. Towards a comprehensive model of comprehension. In Brian Ross (ed.), *The psychology of learning and motivation, vol. 51*, 297-28). New York, NY, US: Elsevier.

Müller, Bettina & Tobias Richter. 2014. Lesekompetenz [Reading competence]. In Joachim Grabowski (ed.), *Sinn und Unsinn von Kompetenzen: Fähigkeitskonzepte im Bereich von Sprache, Medien und Kultur*, 29-49. Opladen, Germany: Budrich.

Nation, Kate. 2005. Children's reading comprehension difficulties. In Margaret. J. Snowling & Charles Hulme (eds.), *The Science of Reading: A Handbook*, 248-265. Oxford, UK: Blackwell.

Nation, Kate & Margaret J. Snowling. 1998. Individual differences in contextual facilitation: Evidence from dyslexia and poor reading comprehension. *Child Development* 69(4). 996-1011.

Nation, Kate & Margaret J. Snowling. 1999. Developmental differences in sensitivity to semantic relations among good and poor comprehenders: Evidence from semantic priming. *Cognition* 70(1). B1-B13.

Nation, Kate & Margaret J. Snowling. 2000. Factors influencing syntactic awareness skills in normal readers and poor comprehenders. *Applied Psycholinguistics* 21(2). 229-241.

Oakhill, Jane V., Kate Cain & Peter E. Bryant. 2003. The dissociation of word reading and text comprehension: Evidence from component skills. *Language and Cognitive Processes* 18(4). 443-468.

Paap, Kenneth R. & Ronald W. Noel. 1991. Dual route models of print to sound: Still a good horse race. *Psychological Research* 53(1). 13-24.

Perfetti, Charles A. 1985. *Reading ability*. New York: Oxford University Press.

Perfetti, Charles A. 2001. Reading skills. In Neil J. Smelser & Paul B. Baltes (eds.), *International encyclopedia of the social & behavioral science*, 12800-12805. Oxford: Pergamon.

Perfetti, Charles A. 2007. Reading ability: Lexical quality to comprehension. *Scientific Studies of Reading* 11(4). 357-383.

Perfetti, Charles A. 2010. Decoding, vocabulary, and comprehension. The golden triangle of reading skill. In Margaret G. McKeown & Linda Kucan (eds.), *Bringing reading research to life: Essays in honor of Isabel Beck*, 291-303. New York, NY: Guilford.

Perfetti, Charles A. & Lesley Hart. 2001. The lexical bases of comprehension skill. In David S. Gorfien (ed.), *On the consequences of meaning selection: Perspectives on resolving lexical ambiguity*, 67-86. Washington, DC: American Psychological Association.

Perfetti, Charles A. & Lesley Hart. 2002. The lexical quality hypothesis. In Ludo Vehoeven. Carsten Elbro & Pieter Reitsma (eds.), *Precursors of functional literacy*, 189-213. Amsterdam: John Benjamins.

Plaut, David C., James L. McClelland, Mark S. Seidenberg & Karalyn Patterson. 1996. Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review* 103(1). 56–115.

Plaut, David C. 1999. A connectionist approach to word reading and acquired dyslexia: Extension to sequential processing. *Cognitive Science* 23(4). 543-568.

Plaza, Monique & Henri Cohen. 2003. The interaction between phonological processing, syntactic awareness, and naming speed in the reading and spelling performance of first-grade children. *Brain and Cognition* 53(2). 287-92.

Rack, John P., Margaret J. Snowling & Richard K. Olson. 1992. The nonword reading deficit in developmental dyslexia: A review. *Reading Research Quarterly* 27(1). 29-53.

Ramus, Franck, Chloe R. Marshall, Stuart Rosen & Heather K. J. van der Lely. 2013. Phonological deficits in specific language impairment and developmental dyslexia: towards a multidimensional model. *Brain* 136(2).630-45.

Ransby, Marilyn. J. & H. Lee Swanson. 2003. Reading comprehension skills of young adults with childhood diagnosis of dyslexia. *Journal of Learning Disabilities* 36(6). 538-555.

Richter, Tobias & Ursula Christmann. 2009. Lesekompetenz: Prozessebenen und interindividuelle Unterschiede [Reading competence: Levels of processing and individual differences]. In Norbert Groeben & Bettina Hurrelmann (eds.), *Lesekompetenz: Bedingungen, Dimensionen, Funktionen*, 25-58, 3rd edn. Weinheim, Germany: Juventa.

Richter, Tobias, Maj-Britt Isberner, Johannes Naumann & Yvonne Neeb. 2013. Lexical quality and reading comprehension in primary school children. *Scientific Studies of Reading* 17(6). 415-434.

Richter, Tobias, Johannes Naumann, Maj-Britt Isberner, Yvonne Neeb & Julia Knoepke. (in press). *ProDi-L: Prozessbezogene Diagnostik des Leseverstehens bei Grundschulkindern* [Process-based assessment of reading skills in primary school children] [Computerized test]. Göttingen, Germany: Hogrefe.

Richter, Tobias, Sascha Schroeder & Britta Wöhrmann. 2009. You don't have to believe everything you read: Background knowledge permits fast and efficient validation of information. *Journal of Personality and Social Psychology* 96(3). 538-558.

Rutter, Michael & William Yule. 1975. The concept of specific reading retardation. *Journal of Child Psychology and Psychiatry* 16(3). 181-197.

Scanlon, Donna M. & Frank R. Vellutino 1996). Prerequisite skills, early instruction, and success in first-grade reading: Selected results from a longitudinal study. *Mental Retardation and Developmental Disabilities Research Reviews* 2(1). 54-63.

Seidenberg, Mark S. & James L. McClelland. 1989. A distributed, developmental model of word recognition and naming. *Psychological Review* 96(4), 523–568.

Shaywitz, Sally E., Michael D. Escobar, Bennett A. Shaywitz, Jack M. Fletcher & Robert Makuch. 1992 Evidence that dyslexia may represent the lower tail of a normal distribution of reading ability. *The New England Journal of Medicine* 326(3). 145-150.

Siegel, Linda S. 1988. Evidence that IQ scores are irrelevant to the definition and analysis of reading disability. *Canadian Journal of Psychology* 42(2). 201-215.

Singer, Murray, Michael Halldorson, Jeffrey C. Lear & Peter Andrusiak. 1992. Validation of causal bridging inferences. *Journal of Memory and Language* 31(4). 507-524.

Snowling, Margaret J. 1980. The development of grapheme-phoneme correspondence in normal and dyslexic readers. *Journal of Experimental Child Psychology* 29(2). 294-305.

Stanovich, Keith E. 1980. Toward an interactive-compensatory model of individual differences in the development of reading fluency. *Reading Research Quarterly* 16(1). 32-71.

Stanovich, Keith E. 1988. Explaining the differences between the dyslexic and the garden-variety poor reader: The phonological-core variable-difference model. *Journal of Learning Disabilities* 21(10). 590-604.

Stanovich, Keith E. 2005. The future of a mistake: Will discrepancy measurement continue to make the learning disabilities field a pseudoscience? *Learning Disability Quarterly* 28(2). 103-106.

Stanovich, Keith E. & Linda S. Siegel. 1994. Phenotypic performance profile of children with reading disabilities: A regression-based test of the phonological-core variable-difference model. *Journal of Educational Psychology* 86(1). 24-53.

Stothard, Susan E. & Charles Hulme. 1992 Reading comprehension difficulties. The role of language comprehension and working memory skills. *Reading and Writing: An*

Interdisciplinary Journal 4(3). 245-256.

Stuebing, Karla K., Jack M. Fletcher, Josette M. LeDoux, G. Reid Lyon, Sally E. Shaywitz & Bennett A. Shaywitz. 2002. Validity of IQ-discrepancy classifications of reading disabilities: A meta-analysis. *American Educational Research Journal* 39(2). 469-518.

Tunmer, William E., Andrew R. Nesdale & A. Douglas Wright. 1987. Syntactic awareness and reading acquisition. *British Journal of Developmental Psychology* 5(1). 25-34.

Van Berkum, Jos J. A., Colin M. Brown, Pienie Zwitserlood, Valesca Kooijman & Peter Hagoort. 2005. Anticipating upcoming words in discourse: Evidence from ERPs and reading times. *Journal of Experimental Psychology: Learning, Memory, & Cognition* 31(3). 443-467.

Van der Schoot, Menno, Alain L. Vasbinder, Tako M. Horsley, Albert Reijntjes & Ernest C. D. M. van Lieshout. 2009. Lexical ambiguity resolution in good and poor comprehenders: An eye fixation and self-paced reading study in primary school children. *Journal of Educational Psychology* 101(1). 21-36.

Van Dijk, Teun A. & Walter Kintsch. 1983. *Strategies of discourse comprehension*. New York: Academic Press.

Vellutino, Frank R., Jack M. Fletcher, Margaret J. Snowling & Donna M. Scanlon. 2004. Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry* 45(1). 2-40.

Vellutino, Frank R., Donna M. Scanlon & G. Reid Lyon. 2000. Differentiating between difficult-to-remediate and readily remediated poor readers. More evidence against the IQ-achievement discrepancy definition of reading disability. *Journal of Learning Disabilities* 33(3). 223-238.

Vidyasagar, Trichur R. & Kristen Pammer. 2010. Dyslexia: A deficit in visuo-spatial attention,

not in phonological processing. *Trends in Cognitive Sciences* 14(2). 57-63.

West, Richard F. & Keith E. Stanovich. 1978. Automatic contextual facilitation in readers of three ages. *Child Development* 49(3). 717-727.

Wilson, Alexander M. & Nonnie K. Lesaux. 2001. Persistence of phonological processing deficits in college students with dyslexia who have age-appropriate reading skills. *Journal of Learning Disabilities* 34(5). 394-400.

Wimmer, Heinz 1996. The nonword reading deficit in developmental dyslexia: Evidence from children learning to read German. *Journal of Experimental Child Psychology* 61(1). 80-90.

Wimmer, Heinz & Usha Goswami. 1994. The influence of orthographic consistency on reading development: Word recognition in English and German children. *Cognition* 51(1). 91–103.

Woollams, Anna M. 2014. Connectionist neuropsychology: Uncovering ultimate causes of acquired dyslexia. *Philosophical Transactions of the Royal Society B* 369(1634). 1-12.

World Health Organization. 2010. *International Classification of Diseases (ICD-10 online).* http://apps.who.int/classifications/icd10/browse/2010/en (accessed 19 September 2014).

Yule, William. 1973. Differential prognosis of reading backwardness and specific reading retardation. *British Journal of Educational Psychology* 43(3). 244-248.

Yule, William, Michael Rutter, Michael Berger & James Thompson. 1974. Over- and under-achievement in reading: Distribution in the general population. *British Journal of Educational Psychology* 44(1). 1-12.

Ziegler, Johannes. C., Conrad Perry & Max Coltheart. 2000. The DRC model of visual word recognition and reading aloud: An extension to German. *European Journal of Cognitive Psychology* 12(3). 413-430.

Ziegler, Johannes C., Conrad Perry, Anna Ma-Wyatt, Diana Ladner & Gerd Schulte-Körne. 2003. Developmental dyslexia in different languages: Language-specific or universal? *Journal of*

Experimental Child Psychology 86(3). 169-193.

Zoccolotti, Pierluigi, Maria De Luca, Enrico Di Pace, Filippo Gasperini, Anna Judica & Donatella Spinelli. 2005. Word length effect in early reading and in developmental dyslexia. *Brain and Language* 93(3). 369-373.