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DOI

[10.1002/dys.1652](https://doi.org/10.1002/dys.1652)

Publication date

2020

Document Version

Final published version

Published in

Dyslexia

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[Link to publication](#)

Citation for published version (APA):

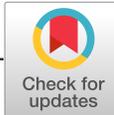
Bazen, L., van den Boer, M., de Jong, P. F., & de Bree, E. H. (2020). Early and late diagnosed dyslexia in secondary school: Performance on literacy skills and cognitive correlates. *Dyslexia*, 26(4), 359-376. <https://doi.org/10.1002/dys.1652>

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RESEARCH ARTICLE

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Early and late diagnosed dyslexia in secondary school: Performance on literacy skills and cognitive correlates

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Funding information

Nederlandse Organisatie voor Wetenschappelijk Onderzoek, Grant/Award Number: 023.005.007

Although a diagnosis of dyslexia is often made during elementary school, severe and persistent literacy difficulties of a considerable group of students are only noticed during secondary school. The question arises whether the literacy (-related) deficits of these late identified students with dyslexia differ from those of early diagnosed students. To address this question, 10th Grade Dutch secondary school students with early ($n = 35$) and late ($n = 19$) identified dyslexia and their peers with average to good literacy abilities ($n = 24$) were compared on literacy skills and underlying cognitive skills. At the group level, both students with an early and late diagnosis performed more poorly than their typical peers, but they did not differ from each other on (pseudo-)word reading, spelling and underlying cognitive correlates (phonemic awareness, rapid automatized naming and visual attention span). The early and late group contained comparable percentages of students performing poorly on most measures. There were, however, more students in the early group who showed deficits in phonemic awareness. Our results indicate that students with early and late diagnosed dyslexia are highly comparable. Suggestions for fitting interventions are discussed.

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KEYWORDS

cognitive correlates, dyslexia, early identification, late identification, literacy

1 | INTRODUCTION

Dyslexia is characterized by difficulties with accurate and/or rapid word reading and/or spelling despite adequate instruction, and in the absence of general cognitive or sensory deficits (Lyon, Shaywitz, & Shaywitz, 2003; Peterson & Pennington, 2015). Although the majority of individuals are diagnosed during early school grades, the diagnosis can be made at any age. A considerable percentage of diagnoses are given after primary school (Cuelenaere, 2016; Snowling, Dawes, Nash, & Hulme, 2012). This has led to studies into the distinction between early and late identified dyslexia. Within these studies, the emphasis tends to be on precursors of later literacy problems and the manifestation of dyslexia during middle elementary school (e.g., Catts, Compton, Tomblin, & Bridges, 2012; Leach, Scarborough, & Rescorla, 2003). The current study focuses on differences between early and late diagnosed students later in education. The main aim is to identify potential differences in word-level literacy skills, as well as associated underlying cognitive abilities between secondary school students with early and late identified dyslexia.

The literacy skills related to dyslexia concern word-level reading and spelling. Regarding underlying cognitive correlates associated with these word-level literacy skills, there is consensus that phonological abilities play an important role (e.g., Ramus, 2003; Velluntino, Fletcher, Snowling, & Scanlon, 2004). Indeed, deficits in phonological abilities are found in the majority of children (e.g., Saksida et al., 2016), adolescents (e.g., Bruck, 1992) and adults (e.g., Ramus et al., 2003; Wilson & Lesaux, 2001) with dyslexia. A phonological deficit is assumed to manifest itself most clearly in tasks tapping phonological awareness (PA), rapid automatized naming (RAN), and verbal short-term memory (VSTM; e.g., Velluntino et al., 2004). Visual attention span (VAS) as a correlate of literacy skills has more recently gained attention (e.g., Bosse, Tainturier, & Valdois, 2007; van den Boer & de Jong, 2018), although it is debated whether this ability is in fact visual, or whether it taps into phonological skills as well (e.g., van den Boer, van Bergen, & de Jong, 2015; Ziegler, Pech-Georgel, Dufau, & Grainger, 2010).

Early and late identified students' performance in literacy skills and underlying cognitive correlates might differ because the late identified students show less severe deficits. Less severe deficits are present but initially missed for some reason. Early deficits may have been floating around the clinical threshold for dyslexia and not have been severe enough to be noticed. New and higher demands on reading and writing during secondary school, such as the introduction of foreign language education, learning through reading, essay writing, but also more challenging aspects of lower-level processes such as decoding and spelling of new and complicated polysyllabic words (Leach et al., 2003), may elicit literacy deficits to become more apparent, and subsequently lead to a dyslexia diagnosis.

In contrast to the option that there is a difference in severity of literacy(-related) performance is the possibility that performance of the early and late-identified groups is actually similar when assessed at secondary education on both literacy outcomes and cognitive correlates. The groups might have shown different performance at earlier ages, but perform similarly at later grades. Indeed, longitudinal studies showed that children with late emerging reading disorders performed within the normal range during Kindergarten and Grade 3, not only on (pre-)literacy skills, but also on measures of underlying cognitive correlates associated with dyslexia (Compton, Fuchs, Fuchs, Elleman, & Gilbert, 2008; Torppa, Eklund, van Bergen, & Lyytinen, 2015). When investigated again in later grades, deficiencies in early and late diagnosed students were highly comparable.

Alternatively, students with late identified dyslexia could have had difficulties early in education that were in fact as severe in nature as those of their late identified peers, yet these difficulties were overlooked, or the students were able to compensate for these deficits through vocabulary and intelligence, for instance (Haft, Myers, & Hoeft, 2016; van Viersen, Kroesbergen, Slot, & de Bree, 2016). Higher demands during secondary school may cause their strategies to become untenable or unsuccessful, forming grounds for clinical assessment and leading to a late diagnosis.

Literacy performance as well as performance in underlying cognitive correlates of these students may at this point turn out to be comparable to that of early diagnosed students. However, in contrast to the option above, a discrepancy between performance on literacy and underlying cognitive correlates may become apparent. Literacy skills might have been compensated for, but this is not necessarily the case for underlying cognitive correlates. Performance on underlying cognitive correlates would then be comparable between early and late diagnosed students, whereas literacy performance might still be better in the late group.

The focus of the current study is on potential differences and/or similarities between early (before secondary school) and late (after the onset of secondary school) diagnosed students in their performance on literacy skills and underlying cognitive correlates during upper secondary school grades. The existing studies that compare early and late dyslexia or reading disability often collapse word-level reading and spelling, as well as reading comprehension problems. Some authors identify poor readers (partly) on the basis of reading comprehension scores (e.g., Compton et al., 2008; Etmanskie, Partanen, & Siegel, 2016). However, dyslexia does not entail comprehension problems per se. Only a few studies provide insight into differences between students with dyslexia on measures of word-level literacy skills and their underlying cognitive correlates.

One such study was conducted by Leach et al. (2003). Early and late diagnosed children as well as typically reading children were investigated in Grades 4 and 5 on word-level reading and spelling skills, as well as on underlying cognitive correlates of reading and spelling. Children in the dyslexia groups all displayed word-level reading deficiencies, with or without additional reading comprehension difficulties. Late identified children performed better than early identified children on (pseudo-)word reading speed and exception word spelling, although they still performed more poorly than their typically developing peers. Performance on other spelling measures and word reading accuracy did not differ between the early and late identified children. The two groups also did not differ on underlying cognitive correlates, including PA and RAN.

Another study into early and late dyslexia was conducted by Lipka, Lesaux, and Siegel (2006). They followed children from Kindergarten until Grade 4. In Grade 4 persistent (early) poor readers, and late emerging poor readers were identified on the basis of a word-level reading test. There were no differences between early and late dyslexia groups in Grade 4 on (pseudo-) word reading and spelling performance. The early identified children performed more poorly than the typical readers on pseudoword reading, but the late identified children did not differ from the typical readers. The dyslexia groups did not differ in phonological processing abilities and were both outperformed by the typical readers.

Catts et al. (2012) aimed to identify the proportion of late emergers and to investigate whether this subtype displayed a specific profile in kindergarten literacy and non-verbal cognitive measures. They followed children from kindergarten until Grade 10. Descriptives show that from Grade 4 onwards, the late identified group, consisting of children with decoding difficulties, scored higher on decoding measures than the group consisting of early identified children. However, as performance between the groups was not compared statistically, these differences in means should be interpreted with caution.

These three studies define a late diagnosis of dyslexia as given from Grade 4 onwards (middle elementary school) and have been conducted in English, an opaque language. A study by Torppa et al. (2015), followed Finnish (a transparent language) speaking secondary school students and defined a late diagnosis as given in Grade 8. Torppa et al. found that typical readers outperformed both dyslexia groups on (pseudo-)word reading speed in Grades 7 and 8. Differences between the dyslexia groups were found only on one of these two reading speed tasks (Grade 7). The late diagnosed students showed better PA than early diagnosed students and their performance was even equal to that of typical readers. The typical readers outperformed the early identified group on VSTM, but there were no other significant differences. The typical readers outperformed both dyslexia groups on RAN; the early and late group did not differ from each other.

Overall, previous studies indicate that differences between early and late groups are found in some but not all measures of word-level literacy skills and underlying cognitive correlates of literacy. When differences arose, early identified students were outperformed by their late identified peers, and both groups were outperformed by typical readers. Differences are most often found on literacy skills and less on underlying cognitive correlates. Importantly, one study found different results, as Torppa et al. (2015) showed that late identified students outperform early

identified students on PA and, to a lesser extent, on VSTM. This study is the only one conducted in a transparent orthography and the only one to look at students whose literacy difficulties were identified in secondary education. Furthermore, previous studies relied on reading disabilities being defined by researchers on the basis of cut-off scores on measures of reading, rather than a clinically-determined dyslexia diagnosis.

1.1 | Current study

In the current study we compared students with a diagnosis of dyslexia obtained at primary school (early), or secondary school (late), and typically reading students. In the Dutch education system, a child can be referred to a diagnostic (and treatment) centre only after the school has tried to remediate the literacy difficulties following a response to instruction approach (e.g., Fuchs & Fuchs, 2006). As a result, early diagnoses are provided in Grade 2 at the earliest, but typically around Grade 4. Our cut-off at Grade 7 for group late was dictated by this relatively “late” onset of dyslexia diagnoses in primary school, as well as the considerable number of diagnoses after the onset of secondary school and substantial changes in the school curriculum from that point with respect to reading and writing.

In addition to overall group comparisons, we considered students' profiles of strengths and weaknesses to provide further information on the differences between early and late diagnosed students with dyslexia and potential heterogeneity of groups. The assumption that multiple risk and protective factors are involved in the development of dyslexia (Pennington, 2006) implies that there might be heterogeneity within the (late) group. This multifactorial nature of dyslexia is visible in findings that not all individuals with dyslexia display phonological disabilities (e.g., Pennington, 2006; Valdois et al., 2003), and that not all people with phonological deficits develop dyslexia (Pennington et al., 2012). Furthermore, it is visible in proposals that certain strengths or less pronounced weaknesses may prevent dyslexia from developing at all, such as IQ and vocabulary (see Haft et al., 2016; van Viersen, de Bree, Kroesbergen, Slot, & de Jong, 2015). Whereas in group analyses individual risk factors such as the number of deficits in underlying cognitive correlates or strengths in the domain of more general abilities may be missed, analyses at the individual level can capture these differences.

This study was conducted among Dutch students in Grade 10. The first aim was to compare students with early (primary school) and late (secondary school) identified dyslexia and typical readers on word-level reading and spelling abilities, and on underlying cognitive correlates of reading. Although reading comprehension is not considered part of dyslexia, we included this as a separate measure in order to relate to earlier studies that examined early versus late dyslexia, and to further clarify the relation between reading comprehension and word-level reading for this age group. The second aim was to examine differences in literacy, underlying cognitive correlates and more general abilities at the individual level in order to establish a more detailed insight in strengths and weaknesses in students with an early or late diagnosis of dyslexia.

Following the assumption that late diagnosed students would show less severe deficits, we expect a stepwise pattern in which early diagnosed students are outperformed by late diagnosed students, and late diagnosed students are outperformed by typically reading students. An alternative option is that there are no clear differences between the early and late groups, and no stepwise pattern. This would be in line with both late emerging and late identified dyslexia in older students. Such a pattern could also point towards compensation mechanisms. It is expected that students who are able to compensate show discrepancies in their profile in which literacy skills are relatively less severely affected than underlying cognitive correlates of dyslexia.

2 | METHOD

2.1 | Participants

A total of 97 Dutch 10th grade secondary school students participated in this study. Students were recruited from nine different secondary schools throughout the Netherlands, as well as through the researchers' networks and

social media. The students with dyslexia were selected on the basis of a clinically determined dyslexia diagnosis. The group of typical readers (group TR) consisted of students with no known reading or spelling difficulties.

Students with a diagnosis given before the onset of secondary school (i.e., before Grade 7) were placed in dyslexia early group, whereas students with a diagnosis given after the onset of secondary school (i.e., in or after Grade 7) were placed in dyslexia late group. For about half of the students in both groups the exact Grade of diagnosis was recorded. On average, students in dyslexia early group were diagnosed in Grade 4, and students in dyslexia group late obtained the diagnosis on average in Grade 8, indicating a mean difference of around 4 years. TR students were selected, if possible from the same classroom as the students with dyslexia, such that they matched the dyslexia groups on gender and school level. Students in all groups stemmed from three different levels in the Dutch educational system which can be described as pre-university education ("vwo," highest level), Higher General Secondary Education ("havo," middle level), and Lower General Secondary Education ("vmbo-t," lowest level).

Forty-one early, 24 late and 31 TR students participated. However, we then selected only those students who scored below the 10th percentile on word- and/or pseudoword reading for the dyslexia groups. Students with a diagnosis of dyslexia, who were not showing word-level reading difficulties at the start of the study, were excluded from the analyses. For the TR group, only students who scored above the 10th percentile on word- and pseudoword reading were selected. As a result, 78 students were included; early ($n = 35$), late ($n = 19$) and TR ($n = 24$). Students' characteristics as well as the distribution of educational levels between dyslexia status groups can be found in Table 1.

The groups did not differ significantly in receptive vocabulary (Dunn & Dunn, 1997), $F(2, 75) = 0.412$, $p = .664$, and non-verbal IQ subtest analogies, $F(2, 77) = 0.407$, $p = .260$ and categories, $F(2, 77) = 0.606$, $p = .548$. School level was controlled for by adding this as an independent factor to the analyses.

2.2 | Instruments

2.2.1 | Non-verbal intelligence

Two subtests of the Snijders-Oomen Niet-Verbale Intelligentietest (*Snijders-Oomen non-verbal Intelligence test*, SON; Tellegen & Laros, 2011) were administered as measures of non-verbal intelligence. In the analogies subtest, each trial consisted of an example of a geometric figure changing into another as the result of one or more alterations. Students were then presented with a new figure and asked to select the correct transformation from four options, following the example analogy. In the categories subtest, students were asked to find a common characteristic (e.g.,

TABLE 1 Participant characteristics divided by group

	Early	Late	TR	Total
N	35	19	24	78
Girls (number and %)	16 (46%)	9 (47%)	13 (54%)	38 (53%)
Mean age (SD in months)	16;5 (9.61)	16;7 (9.02)	16;5 (7.18)	16;5 (8.65)
School level (number and %)				
Low	8 (42%)	3 (16%)	8 (52%)	19
Middle	15 (50%)	6 (20%)	9 (30%)	30
High	12 (41%)	10 (34%)	7 (24%)	29
Non-verbal IQ				
Analogies subtest	28.43 (4.41)	28.11 (4.43)	29.04 (3.83)	28.29 (4.21)
Categories subtest	27.09 (5.89)	28.05 (3.49)	26.54 (3.90)	29.15 (4.80)
Vocabulary	159.38 (12.31)	160.79 (11.80)	160.52 (12.95)	160.08 (12.39)

“movement” or “masculine”) in three given pictures, and select two pictures with that same characteristic from an additional five pictures. Both subtests consisted of three sets of 12 items. Each set was discontinued after two incorrect answers, and the next set was started at the number of the last item of the preceding set minus two. Raw scores, used for the group analyses, consisted of the sum of correct answers for each set (last item minus number of mistakes). Individual analyses were based on age-referenced norm scores ($M = 10$, $SD = 3$). Test-retest reliability was .89 for the analogies, and .90 for the categories subtest (Tellegen & Laros, 2011).

2.2.2 | Vocabulary

Vocabulary was assessed with a computerized Dutch version of the Peabody Picture Vocabulary Task (Dunn & Dunn, 1997). Participants were presented with four semantically related pictures on the screen and with an orally presented word. They were asked to select the picture that best resembled this target. The starting set was selected on the basis of age. Each set consisted of 11 items, the total number of sets was 17. The task was discontinued when more than nine incorrect answers had been given within a set. Raw scores were determined by taking the number of the last item of the final set and subtracting the number of mistakes made from the starting set until there, and were converted to age-referenced norm scores (WBQ, word comprehension quotient, $M = 100$, $SD = 15$). Internal consistency for this task and mean age of the participants was .93 (Dunn & Dunn, 1997).

2.2.3 | Word reading

Word reading fluency was assessed with the one minute test, version B (*Een minuut taak*; Brus & Voeten, 1999). The task consists of a list of 116 words of increasing length and difficulty, presented in four columns of 29 words each. Students were asked to read the words aloud as quickly and accurately as possible within 1 min. Raw scores consisted of the number of items read correctly and were used for the group analysis. Percentile scores for the individual analyses were calculated based on grade and education level (Kuijpers et al., 2003). Test-retest reliability is reported to be between .89 and .92 for this task (Brus & Voeten, 1999).

2.2.4 | Pseudoword reading

Pseudoword reading fluency was assessed with the Klepel task (van den Bos, Lutje Spelberg, Scheepstra, & de Vries, 1994), version B. The task consists of a list of 116 pseudowords of increasing length and difficulty, presented in four columns of 29 words each. Students were asked to read the pseudowords aloud as quickly and accurately as possible within 1 min. Raw scores consisted of the number of items read correctly and were used for the group analysis. Percentile scores for the individual analyses were calculated based on grade and education level (Kuijpers et al., 2003). Test-retest reliability is .91 for this task (van den Bos et al., 1994).

2.2.5 | Spelling

Spelling was assessed by dictating nine sentences of a Dutch standardized spelling task “Het wonderlijke weer” (*The miraculous weather*), which is part of the indicative measurements suggested in the Dutch protocol for dyslexia in secondary school (Henneman, Bekebrede, Cox, & Krosse, 2013). Sentences were read aloud by the experimenter, and were repeated in smaller chunks. Students were asked to write the sentences down as accurately as possible. Scores reflected the number of incorrect words per sentence: the total number of words spelled incorrectly, divided

by the number of sentences. Since no norm scores are available for Grade 10 students, an age referenced norm-score was derived from the TR group in this study. Group analyses were performed with raw scores, individual analyses on the basis of normed scores, formulated on the basis of our TR group's mean (1 *SD* above the TR's mean = strong, 1 *SD* below the TR's mean = weak).

2.2.6 | Reading comprehension

Reading comprehension was assessed through two texts that had been part of the 2013 nation-wide Dutch final exams, provided by CITO. The task consisted of one text and questions each from the VMBO-t exam "Eten en snoep bekenen kleur" (*Food and candy take sides*; CITO, 2013) and the HAVO exam "Nederland talenland?" (*the Netherlands, country of languages?*; CITO, 2013). The texts were 725 and 791 words long, respectively, and were followed by multiple choice and open questions. A total of 18 questions, nine for each text, were presented to the students. For each multiple choice question answered correctly, one point was awarded; points for open questions varied from one to four. A total of 22 points could be scored, and individual scores consisted of the number of points earned by the participant. Group analyses were performed with raw scores, individual analyses on the basis of norm scores, derived on the basis of our TR group's mean (1 *SD* or more above the TR's mean = strong, 1 *SD* or more below the TR's mean = weak).

2.2.7 | Phonological awareness

PA was assessed by a computerized version of a phoneme deletion task (de Jong & van der Leij, 2003). The task consisted of 12 items in total. Students were asked to repeat a given non-word and then to alter it by deleting a given phoneme. The first set consisted of four monosyllabic and four bisyllabic words in which one phoneme had to be deleted (e.g., "repeat 'tral"; "What is 'tral' without 'r'?"); the second set consisted of four bisyllabic items in which the phoneme occurred twice in each item (e.g., gepgral without 'g'). Each set was preceded by two practice items. To avoid ceiling effects, a fluency score was used in the analyses. The score was derived following van Bergen, Bishop, van Zuijlen, and de Jong (2015), from the median of response times in milliseconds, converted to the number of items correct per minute and multiplied by the proportion correct. Group analyses were performed with raw scores, individual analyses using norm scores, derived on the basis of our TR group's mean (1 *SD* or more above the TR's mean = strong, 1 *SD* or more below the TR's mean = weak).

2.2.8 | Rapid automatized naming

To assess RAN, the subtests Letters and Digits of the Test of Continu Benoemen & Woorden Lezen (*Continuous naming & word reading*, van den Bos & Lutje Spelberg, 2007) were administered. Students were asked to name numbers (2, 4, 8, 5 and 9) and letters (d, o, a, s and p) as quickly and accurately as possible. Both cards consisted of five columns of 10 items in semi-random order. Scores consisted of the number of correct items read per second. Group analyses were performed with raw scores, individual analyses on the basis of norm scores, derived on the basis of our TR group's mean (1 *SD* or more above the TR's mean = strong, 1 *SD* or more below the TR's mean = weak).

2.2.9 | Verbal short-term memory

VSTM was measured with the Digit Span Forward and Digit Span Backward tasks of the Wechsler Intelligence Scale for Children-III (WISC III, Kort et al., 2005). In the forward task, students heard sequences of digits that they had to repeat. In

the backwards task, students heard the sequences but had to produce them in reverse order. Sequences increased in length, ranging from 2 to a maximum of 9 digits for Digit Span Forward and to a maximum of 8 digits for Digit Span Backward. Tasks were discontinued when both sequences of the same length were repeated incorrectly. The score consisted of the number of sequences repeated correctly. Group analyses were performed with raw scores, individual analyses on the basis of age-referenced norm scores ($M = 10$, $SD = 3$). Test-retest reliability is .70 (Kort et al., 2005).

2.2.10 | Visual attention span

VAS was measured by a whole report task (based on Valdois et al., 2003), in which students were asked to repeat as many letters as possible from 10 strings of 5 (first set), and 12 strings of 6 letters (second set) presented to them. Strings were composed of 10 consonants (B, D, R, H, L, M, P, R, S and T). They were presented on a laptop screen through Microsoft PowerPoint for 200 ms in bold 28-point Arial font, each time preceded by a plus sign for 1,000 ms to focus attention. Five practice strings were presented prior to the task. The score consisted of the number of letters repeated correctly in the correct position within the string (from a total of 122). Group analyses were performed with raw scores, individual analyses on the basis of norm scores, derived on the basis of our TR group's mean (1 *SD* or more above the TR's mean = strong, 1 *SD* or more below the TR's mean = weak).

2.3 | Procedure

Tasks described above were part of a larger test battery. Total assessment consisted of two individual sessions of 45–60 min, and one 60 min session which could be performed group-wise. All tasks were administered in Grade 10. Test sessions were administered by the first author and trained test assistants. Most sessions took place in schools, some took place at the university or at participant's homes. Prior to data collection, approval was obtained from the Ethics Review Board of the Faculty Social and Behavioral Sciences of the University of Amsterdam (project number 2015-CDE-4749).

2.4 | Analyses

In order to compare the groups on the measures of literacy skills and cognitive correlates of literacy skills, ANOVAs with task outcome and group (TR, early, late) were conducted. In the case of word reading, a MANOVA was first performed with word reading efficiency (word reading, pseudoword reading) and dyslexia status. In order to control for school level (high level, medium level and low level of education), this variable was added to all ANOVA analyses as a blocking factor. When main effects for group were attested, Helmert contrasts were conducted to specify the differences between these groups (see Field, 2013), for which contrast estimates (CE) rather than *F*-values were provided. These contrasts allowed us to take school level into account in the follow-up comparisons. In each first contrast, the TR group was compared to the two dyslexia groups together (TR vs. dyslexia). In the second contrast, the two dyslexia groups were compared to each other (early vs. late).

In order to evaluate strengths and weaknesses across the literacy measures of students in the dyslexia groups, cognitive correlates, as well as intelligence and vocabulary at an individual level, a case series analysis was performed. To determine strengths and weaknesses, norm scores were used when available. (Pseudo)Word reading scores below the 10th percentile were considered weak, above the 10th percentile strong. For all other measures the cut-off for a weakness was 1 *SD* below the mean of TR group, and for a strength 1 *SD* above the mean. Percentages of weaknesses and strengths per skill between groups, as well as odds ratios of weaknesses (the chance of a participant in early group to show a certain weakness compared to a participant in late group) were calculated.

TABLE 2 Outcomes on literacy and underlying cognitive correlates; univariate two-way-ANOVAs with planned (Helmert) contrasts

	Early			Late			TR			F	p
	N	M (SD)	Range	N	M (SD)	Range	N	M (SD)	Range		
Word reading	35	72.32 (9.11)	50–103	19	71.03 (12.06)	56–88	24	96.67 ^a (11.60)	74–116	13.25	<.001
Pseudoword reading	35	54.69 (12.93)	24–87	19	64.95 (11.98)	40–100	24	88.17 ^a (16.35)	61–114	57.07	<.001
Spelling	33	1.08 (.58)	.22–2.22	19	.80 (.41)	.11–1.44	23	.41 ^a (.33)	.00–1.33	13.81	<.001
Reading comprehension	33	12.85 (4.21)	2–23	18	14.39 (5.59)	2–22	23	14.61 (5.06)	5–24	2.34	.105
PA	34	13.17 (6.31)	3.28–26.93	19	16.93 (7.19)	9.01–36.04	24	21.64 ^a (8.86)	5.23–42.00	9.17	<.001
RAN	35	2.40 (.40)	1.53–3.75	19	2.38 (.50)	1.34–3.59	24	2.90 ^a (.43)	2.10–3.87	15.66	<.001
VAS	35	88.40 (11.53)	59–111	19	90.74 (14.33)	59–115	23	96.52 ^a (13.50)	67–114	3.30	.044
VSTM	35	15.09 (3.64)	10–24	19	15.63 (2.69)	10–19	24	16.42 (3.00)	11–22	1.18	.315

Note: Helmert contrasts included TR vs. early + late and early vs. late.

^aSignificant difference ($p < .05$) between TR and early + late.

3 | RESULTS

3.1 | Data screening

There were several missing scores due to errors in test administration, or absence of a student during (part of) a session in spelling (3), reading comprehension (4), VAS (1) and PA (1). Analyses were conducted without these scores, as removing students with missing scores from other parts of the analysis did not alter our results. Within the TR group one participant obtained a PA score more than three standard deviations above the mean. Excluding this score did not alter our results, so it was kept in the analyses. All variables were normally distributed.

3.2 | Group analyses

3.2.1 | Literacy skills

The means and standard deviations for all literacy measures as well as the main effects of our group analyses are reported in Table 2. A MANOVA with word and pseudoword reading speed as dependent variables, and group (TR, early, late) and school level as between-subjects factors showed a multivariate effect on reading, Pillai's trace = 0.74, $F(4, 138) = 20.37$, $p < .001$. No significant interaction effects were found between school level and group (early, late, TR), indicating that all results could be interpreted independent of school level. As the factor school level is not of interest for the current study, we only report the results on differences among the three groups.

The univariate ANOVAs also showed main effects for group on word and pseudoword reading fluency (see Table 2). To examine differences between groups, Helmert contrasts were performed. The combined dyslexia groups obtained significantly lower scores than the TR group on word reading fluency, $CE = 26.77$, $p < .001$ and on pseudoword reading $CE = 30.88$, $p < .001$. The second comparison revealed that the early and late groups did not differ from each other on word reading fluency, $CE = -1.18$, $p = .724$. The groups also did not differ on pseudoword reading, although this difference was almost significant, $CE = 7.50$, $p = .053$. For spelling, a univariate ANOVA also showed a main effect of group (see Table 2). The first Helmert contrast indicated that the dyslexia groups combined obtained significantly lower scores than the TR group, $CE = -0.59$, $p < .001$. The second contrast revealed that the dyslexia groups did not differ from each other $CE = -0.19$, $p = .195$. A univariate ANOVA showed that the three groups did not differ in reading comprehension (see Table 2).

3.2.2 | Underlying cognitive correlates

The means and standard deviations for all underlying cognitive correlates of reading as well as the main effects of our group analyses are reported in Table 2. There were no significant interaction effects between school level and group (early, late, TR). Analyses on the cognitive correlates PA, RAN and VAS showed a consistent pattern, as ANOVAs showed a main effect of group, with the combined dyslexia groups obtaining significantly lower scores than the TR group (PA: $CE = 6.61$, $p < .001$; RAN: $CE = 0.58$, $p < .001$ and VAS: $CE = 8.13$, $p = .019$) and the early and late groups not differing significantly from each other (PA: $CE = 4.51$, $p = .081$; RAN: $CE = -0.16$, $p = .197$ and VAS: $CE = 1.21$, $p = .764$). There were no group differences on VSTM.

TABLE 3 Summary of case series analysis

	Word level literacy			Underlying cognitive correlates				General abilities			
	Word reading	Pseudoword reading	Spelling	Reading comprehension	RAN	PA	VSTM	VAS	Receptive vocabulary	Non-verbal IQ categories	Non-verbal IQ analogies
Early, N = 35											
Nr weaknesses	25	31	22	7	22	21	5	11	0	3	1
Nr strengths	—	—	0	1	1	0	5	1	0	5	8
% weaknesses	71%	89%	63%	20%	63%	60%	14%	31%	0%	9%	2%
% strengths	—	—	0%	3%	3%	0%	14%	3%	0%	14%	22%
Late, N = 19											
Nr weaknesses	14	13	11	3	12	6	2	5	0	0	1
Nr strengths	—	—	0	2	1	1	0	1	0	2	2
% weaknesses	74%	68%	58%	16%	63%	32%	11%	26%	0%	0%	5%
% strengths	—	—	0%	11%	5%	5%	0%	5%	0%	11%	11%
Odds ratios	0.89	3.58	1.23	1.33	0.99	3.25	1.42	1.28	—	—	0.53
Early: late											

3.2.3 | Case series

A summary of the case series results is reported in Table 3, which contains numbers and percentages of weaknesses and strengths per group, as well as odds ratios. All individual profiles can be found in the Supporting information.

With respect to literacy performance, percentages of students with weaknesses in word reading fluency were equally high (early 72% and late 71%). However, a higher percentage of students in the early group displayed weaknesses in pseudoword reading fluency (early 89% and late 68%), reflected in an odds ratio of 3.58, approaching significance ($\chi^2(1) = 3.14, p = .069$). The percentage of weak spellers was somewhat higher in early than in late (63 vs. 58%). Both groups contained a substantial number of students that did not display spelling weaknesses despite weakness in (pseudo-)word reading. Comparable percentages of students with weaknesses in reading comprehension were found in both groups (early 20% and late 16%). A strength in literacy skills was, as expected, rare (early 3% and late 11%), and only found in reading comprehension.

With respect to the risk factors, the underlying cognitive correlates of dyslexia, we found that the percentages of students with weaknesses in RAN were similar (63%) in both groups. Students in the early group more often showed a weaknesses in PA (60%) than in the late group (32%). This is reflected in the significant odds ratio (3.25), $\chi^2(1) = 3.98, p = .046$. Percentages of students with weaknesses in VAS were comparable in both groups (early 31% and late 26%). The same was true for performance on VSTM, although in both groups only a limited number of students showed weaknesses in this domain (14% in early, 11% in late). Although the average number of deficits (maximum of four) on the underlying cognitive correlates was somewhat higher in the early group ($M = 1.69, SD = 1.18$) than the late group ($M = 1.32, SD = 1.00$), this difference was not significant on an independent samples *t* test, $t(52) = 1.16, p = .196$.

Percentages of strengths on underlying cognitive correlates of dyslexia were not high in either group, although some students in the early group showed a strength in VSTM (early 14% and late 0%). This was also the case for non-verbal IQ and vocabulary, although a higher percentage of students in the early group showed a strength in one of our measures of non-verbal intelligence than in the late group (early 22% and late 11%).

In sum, the case series analysis showed minimal differences between groups, except for PA, a significant difference, and pseudoword reading, nearing significance. Generally for both groups, the highest numbers of weaknesses were found on word-level literacy skills, followed by RAN and PA. Low numbers of weaknesses were found on VSTM, reading comprehension, vocabulary and non-verbal IQ. Strengths were rare in all skills.

4 | DISCUSSION

Despite considerable numbers of students receiving a dyslexia diagnosis during secondary school, relatively little is known about their performance when compared to their peers that obtained a diagnosis during primary school. The current study examined the similarities and differences in literacy skills and underlying literacy-related cognitive abilities between secondary school students with early and late diagnosed dyslexia as well as with their typically reading peers. Overall, our results at the group level did not show any differences between students that were diagnosed already in primary school and those that were diagnosed in secondary education, neither on literacy skills nor on underlying literacy-related cognitive abilities. As expected, both groups of students with dyslexia performed worse on word-level reading and spelling than the typically reading students. With the exception of VSTM, their performance was also lower on the underlying cognitive abilities (PA, RAN and VAS). Somewhat surprisingly, we found no significant differences between any of the groups (dyslexia and TR) in reading comprehension.

The case series analysis largely confirmed our results at the group level. Heterogeneous profiles of literacy and literacy-related cognitive abilities in both the early and late diagnosed dyslexia groups in terms of weaknesses and strengths were found. Except for PA, the number of students with weaknesses and strengths was comparable in both groups with dyslexia. For PA, there were more students with a deficit in the early than in the late group, a

difference that we did not observe in the mean performance of the group. The average number of underlying cognitive deficits per student was similar in both dyslexia groups. In sum, both the group analysis and case series showed minimal differences between early and late identified students with dyslexia. An exception is the better performance in PA in late group, yet this difference was inconsistent in our analyses. Our findings on PA speak to the study by Torppa et al. (2015) among somewhat younger secondary school students in a transparent language. They showed that PA outcomes of late identified students were significantly higher than those of early identified students. This difference was not present on RAN and VSTM. PA forms the basis for the initial stages of literacy learning especially (de Jong & van der Leij, 2003; Papadopoulos, Spanoudis, & Georgiou, 2016), whereas other abilities, for example RAN, contribute to literacy learning throughout development (Manis, Seidenberg, & Doi, 1999; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997; Wimmer, 1993). Research into resolving dyslexia has shown that adults with resolved childhood dyslexia display PA performance that is comparable to that of adults with unresolved dyslexia, whereas RAN performance of resolvers resembles that of typical readers (Eloranta, Närhi, Eklund, Ahonen, & Aro, 2018). These findings indicate that while poor PA may hamper literacy development in early stages especially, later problems may occur and remain as a result of deficiencies in other abilities such as RAN.

The pattern of findings of our study agrees with previous studies that also reported similar performance levels of early and late identified students on most literacy skills (e.g., Catts et al., 2012; Leach et al., 2003; Lipka et al., 2006; Torppa et al., 2015). It should be noted that the age groups in the current study are different from those in previous studies. Whereas the cut-off for early versus late is made in Grade 4 for most previous studies, it was Grade 7 in the current study (which is in line with Torppa et al., 2015). This difference should be taken into account when comparing the current study to previous studies. Because our groups do not differ, it does not seem to be the case that the literacy deficits of the late diagnosed children are milder. Therefore, the current findings discard the explanation that late identification of dyslexia occurs when mild literacy problems of late diagnosed students only become manifest when environmental literacy requirements increase (e.g., more reading, more difficult texts), also for students identified after the onset of secondary school. This leaves us with two further possibilities as to why some students' literacy difficulties lead to an early diagnosis and those of others only at secondary school.

One possibility is that children in the late group may have been able to compensate for literacy difficulties during the primary school years, but no longer at secondary school. If this were the case, then strengths that enable masking or compensation would be expected in this group (see Haft et al., 2016; van Viersen et al., 2016; van Viersen, de Bree, & de Jong, 2019). However, the group with a late diagnosis did not perform better on any skill including non-verbal IQ and vocabulary. In addition, the late group did not display a discrepancy with relatively high literacy performance as compared to underlying cognitive correlates. An important note here is that given the concurrent design of this study, is it not possible to evaluate possible compensation at a younger age. Still, our study does not support the hypothesis that late diagnoses are the result of a compensation mechanism when these skills are assessed in Grade 10.

A second possibility for early versus late diagnoses is that deficits in group late are truly late emerging. Previous longitudinal studies show evidence for late emergence of reading disorders (Catts et al., 2012; Lipka et al., 2006; Torppa et al., 2015). In these studies, late identified children scored within the normal range during elementary school and early school grades, yet moved to the lower performance level of early identified peers throughout the years. Our findings, based on assessments at a relatively late age, largely resemble the findings of the older students in these studies.

Two further possibilities relate to limitations of the current study, as SES and treatment background were not taken into account. The reading and spelling problems of late diagnosed students might in some cases simply have been missed or ignored by caregivers and/or teachers. For example, it has been reported that parents with lower SES are less inclined to self-report dyslexia and experience less burden despite severe literacy difficulties (Leavett, Nash, & Snowling, 2014; Macdonald & Deacon, 2019). As a result they may be less likely to address learning problems of their children. Indications of SES were not included in the current study. However, the Dutch school system includes a thorough, standardized reading screening system: Children's reading progress is monitored by assessments twice a year during elementary school (Gijssels, Scheltinga, Druenen, & Verhoeven, 2011, based on Fuchs & Fuchs, 2006; Vaughn & Fuchs, 2003). When performance is below average on a particular assessment, the child receives

targeted intervention within the school. When intervention results in insufficient progress, children are referred to health care institutes for diagnosis and treatment. Within this structured system of monitoring and intervention in schools, it seems unlikely that external factors such as SES and inattentiveness of teachers and caregivers form a major explanation for late diagnoses.

The second issue concerns the difference in remediation opportunity between the groups. Early identified students undergo early intervention programs and/or remedial teaching in order to improve reading skills (e.g., Ehrhardt, Huntington, Molino, & Barbaresi, 2013; Eloranta et al., 2018; Tijms, 2011). In contrast, late identified students are less likely to have been offered intervention programs at that time. This lack of support can cause problems to become more severe (see Tijms, 2011). Similar performance in early and late groups in adolescence could hypothetically at least partly represent training effects that caused the performance of the groups to move closer to each other. However, it is unknown what the effect of support in early educational years is for the students in our early group, as studies with follow-ups of more than 2 years are almost absent (see Suggate, 2016). Future longitudinal studies that specifically take training effects into account may shed light on this issue.

A factor that complicates a direct comparison with earlier studies, in addition to differences in age and language, is our rigid selection procedure. We initially selected students on the basis of a dyslexia diagnosis, provided by a healthcare professional (SDN et al., 2016). Of our initial group, we excluded students whose word reading and/or pseudoword reading performance were above the cut-off (above the tenth percentile) for a diagnosis, to be sure of the literacy deficit at the time of testing in Grade 10. This approach also meant that students in the TR group with poor literacy skills were excluded from the study, contrary to some previous studies that based their inclusion criteria on single measurements. Our reliance on strict criteria might therefore have led to different results compared to studies that used concurrent outcomes (e.g., Torppa et al., 2015) and less strict criteria (e.g., Leach et al., 2003).

Comparable performance between dyslexia groups was shown in most of our variables. However, the absence of evidence for differences is not necessarily the same as evidence for absence of differences between dyslexia groups. The small sample size of the current study forms a limitation in interpreting our findings, especially those that showed trends in means in which group late outperforms group early. Variables that relate to phonology, PA and pseudoword reading, showed this trend in the current group analyses and showed differences at the individual level on pseudoword reading performance. Indeed, the study that is most comparable to the current study in terms of age and language by Torppa et al. (2015) indicated that late outperformed early on PA performance. Replication of the current study in a bigger sample may show these differences between groups as well.

Criteria for dyslexia are based on word-level reading and spelling skills, and these skills therefore formed the basis of our selection criteria. However, we also assessed reading comprehension. No differences in reading comprehension performance were found between any of our groups. This finding in itself is interesting, given that according to reading comprehension theories such as the Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) deficits in decoding skills displayed in our dyslexia groups should be reflected in comprehension performance. However, despite poor decoding skills, students with both early and late diagnosed dyslexia did not show comprehension deficits. This is in line with earlier research indicating that with age the role of linguistic comprehension in reading comprehension increases, whereas the role of decoding skills decreases (e.g., García & Cain, 2014; Landi, 2010; Lonigan, Burgess, & Schatschneider, 2018; Tilstra, McMaster, Van den Broek, Kendeou, & Rapp, 2009).

The finding that early and late identified secondary school students with dyslexia show highly similar performance has educational implications. Students of both groups should be offered the same compensation opportunities as well as remediation or intervention programs devoted to improvement of literacy skills. Special attention should therein be devoted to late identified students, given their inherently later onset of support. Most remediation programs as well as diagnostic instruments have, however, been developed for younger students (e.g., Regtvoort, Zijlstra, & van der Leij, 2013; Snowling, 2013; Tijms, 2011) and little is known about suitable ways to support older students with dyslexia. For example, most studies towards interventions focus on basic literacy skills, whereas more advanced skills such as silent reading (Gagliano et al., 2015), foreign language learning and advanced spelling receive less attention. Also, self-esteem and self-efficacy (Burns, Poikkeus, & Aro, 2013), have been shown to play an important role, and may form a basis for

additional interventions. Research has shown that intervention at a later age can be highly effective (e.g., Tijms, Hoeks, Paulussen-Hoogbeem, & Smolenaars, 2003). For these reasons, we emphasize the importance of future research towards effective ways to support secondary school students with dyslexia, both early and late diagnosed.

5 | CONCLUSIONS

The current study shows that impairments of early and late identified students with dyslexia were largely similar, as they showed comparable performance on literacy skills and underlying cognitive correlates. Although in the early diagnosed group a larger percentage of students showed difficulties on PA, no significant differences emerged on PA and other measures in group mean comparisons. Differences between early and late identified students are too small to warrant the hypothesis that late identified students are less severely impaired. Our results suggest that deficits in late identified students may have been late emerging. Results prompt further longitudinal research as well as research towards effective intervention programs for secondary school students with early and late diagnosed dyslexia.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Bazen L, van den Boer M, de Jong PF, de Bree EH. Early and late diagnosed dyslexia in secondary school: Performance on literacy skills and cognitive correlates. *Dyslexia*. 2020;26:359–376.

<https://doi.org/10.1002/dys.1652>