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Do students with Down syndrome have a specific learning profile for reading?

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ABSTRACT

The present study assessed achieved reading stages of 190 school-aged children with Down syndrome (DS, age 6–20) in Bavaria, one of the most populated federal states in Germany. Teachers described the reading stages of their students in a questionnaire. The achieved stages of reading according to the developmental model of Frith are compared to a sample of 1419 students with intellectual disability (ID) regardless of etiology, but excluding DS; thereafter parallelized ID-groups were compared.

Results of the questionnaire addressed to the students' teachers showed that 20.2% of the students with DS do not read at all, 7.6% read at a logographic stage, 49.4% at an alphabetic and 22.8% at an orthographic level. Alongside these findings among the whole sample, correlations are described concerning age, gender, IQ and sociocultural background. The students with DS are then compared to other students with ID with mixed etiologies. This comparison stresses the emphasis on the alphabetic level amongst students with DS. This emphasis also exists when DS and non-DS students are parallelized in groups of ID, thus showing that students with DS and severe ID are ahead in reading, but those with mild ID are behind.

Knowledge about specific literacy attainment of students with DS is vital for planning instruction, for creating learning environments, and for formulating future fields of research. Especially students with DS need specific teaching which takes their impaired verbal short term memory into account, such as learning to read in syllables.

1. Introduction

There is some evidence available that students with Down syndrome (DS) achieve considerable levels of reading (e.g., Baylis & Snowling, 2012; Byrne, Buckley, MacDonald, & Bird, 1995; Byrne, MacDonald, & Buckley, 2002; Fletcher & Buckley, 2002; Roch & Jarrold, 2008; Verucci, Menghini, & Vicari, 2006). Buckley's (1985) suggestion that reading might be an "island of ability" in DS has been heavily criticized by Cardoso-Martins, Peterson, Olson, and Pennington (2009) who find it "surprising that they learn to read at all, not to mention well", due to their language and speech deficits. Objectives of such studies, however, have generally been rather specific questions, mainly on the aspect of phoneme awareness, seeking the understanding of the learning process in reading.

More precise studies about the reading achievements of students with DS have been sparse and small-scale and therefore not representative. In studies about reading achievements of students with ID in general, students with DS are often included but not specifically mentioned – and these studies are sparse, too.

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Byrne et al. (1995) found an extremely broad variety of reading abilities among 24 students with Down syndrome, and mention that as many as half of students with DS read at least 50 words (Buckley, Bird, & Byrne, 1996). These students were traced in a two-year longitudinal study, finding them to progress significantly with single word reading, but progressing very slowly with reading comprehension (Byrne et al., 2002). Turner, Alborz and Gayle (2008) found severity of intellectual impairment to be by far the most significant predictor, but sum up that mainstream school attendance only had a modest beneficial effect on academic skills ($N = 71$).

Other studies looked at students with ID in general, which is an important comparison: Katims (2001) examined a sample of 132 students in Texas and found 22% of them showing the full criteria of "minimal literacy", including the ability to "(1) recognize words within a narrative passage from an analytical reading inventory at least on the primer level; (2) comprehend a narrative passage from an analytical reading inventory at least on the primer level; (3) write at least 2 letters or letter combinations representing sounds in words on a phonemic awareness dictation task, and; (4) write at least two words containing two or more letters each correctly spelled on a free-writing task" (Katims, 2001, 363). Koch (2008) also reports extreme differences between two schools for students with ID in Germany. In one school 42% of the students were found to be reading at an alphabetical level, in the other school only 7% read at the same stage. Ratz and Lenhard (2013) conducted a study in German schools for ID questioning teachers, showing that among all students ($N = 1629$) in these schools and regardless of diagnosis 29.3% do not read at all, 6.8% read at a logographic stage, 31.9% at an alphabetic and 32% at an orthographic level.

The present study takes a step backwards and focuses on prevalence of reading for the first time in a large and representative sample of students with DS. Combining prevalence with a developmental model of reading may take a view on the process of learning to read from another perspective, and thereby discuss previous research outcomes. The question whether there is a specific profile in reading for individuals with DS compared to other students with ID is especially interesting as there is a lot of specific knowledge about DS available which can be used to discuss the results – in comparison, other diagnoses have been far less researched. Finding a specific profile in the reading development of students with DS offers important information for educational concepts, in special education classes as well as in inclusive settings.

Previous research has discussed the specific role of phonological awareness (PA) among students with DS when learning to read. PA is an important predictor of future reading ability and there has been much research into the question whether PA plays the same role in the development of reading abilities for children with DS as for typically developing children (e.g., Verucci et al., 2006). Cossu, Rossini, and Marshall (1993) described Italian students with Down syndrome who were able to read, but showed no PA abilities. Intensive research followed, criticizing methodological aspects (Byrne, 1993; Morton & Frith, 1993), and establishing evidence that students with Down syndrome do show PA (e.g. Cupples & Iacono, 2000, 2002; Fowler, Doherty, & Boynton, 1995; Goetz et al., 2008; Laws & Gunn, 2002; Snowling, Hulme, & Mercer, 2002). Similar evidence has been described in regard to various languages such as French (Gombert, 2002), Italian (Verucci et al., 2006) and German (Koch, 2008). This discussion has set the focus on a more differentiated view of PA, e.g. showing that rhyming is not as important for developing reading abilities as phoneme segmentation (Melby-Lervåg, Lyster, & Hulme, 2012). This may in fact shift the importance of PA in general to a more specific view, emphasizing only certain aspects and avoiding others such as rhyming and "odd one out" (Koch, 2008; Roch & Jarrold, 2008). Ultimately, this research shows that students with DS do display PA abilities, but the weight of evidence suggests that this is poorer than their reading level and is correlated with reading at a lower level than in typical development (Lemons & Fuchs, 2010; Næss, Lyster, Hulme, & Melby-Lervåg, 2011). Groen, Laws, Nation, and Bishop (2006) have even reported a case of DS with exceptional reading accuracy, associated with robust phonological skills. Baylis and Snowling (2012) assume them to use different strategies in learning to read in comparison to typically developing children. All these aspects may have been one reason why the whole word approach or sight word reading is often recommended for teaching students with DS: (e.g. Oelwein, 1995, which is also available in German; Baylis & Snowling, 2012; Fidler, Most, & Guiberson, 2005). This may be successful for increasing the number of words to be read, but does not foster the phonological pathway which is the foundation for orthographic reading. Reading instruction including PA and readings skills, however, shows to be beneficial for students in some recent studies for students with ID (Browder, Ahlgrim-Delzell, Flowers, & Baker, 2012) as well as for students with DS (Burgoyne et al., 2012; Cologon, Cupples, & Wyver, 2011).

Another issue related to developing reading abilities is the short term memory (STM). Again, DS has been in the focus of research, and a specific profile of their STM has been described (Frenkel & Bourdin, 2009; Jarrold & Baddeley, 2001). Children with Down syndrome seem to display a specific deficit in verbal STM, in contrast to visual and spacial material. For example, Kay-Raining Bird and Chapman (1994) found a common verbal digit span for individuals with Down syndrome of 4, compared with 5 in typically developing children at an equivalent level of intellectual functioning. Recently, Purser and Jarrold (2013) found evidence that this verbal STM deficit does not underlie skills in phonemic discrimination. The impact of this profile of verbal STM deficit on reading is evident, as when sounding out a word phoneme by phoneme one has to remember the phonemes at the beginning of the word in order to finally recognize the word.

Other objectives of studies seeking to learn more about reading development in DS have been reading comprehension (Levorato, Roch, & Beltrame, 2009; Roch & Levorato, 2010), language (Burgoyne et al., 2012), eye-movement patterns (Frenck-Mestre, Zardan, Colas, & Ghio, 2010) and neuropsychological correlates of word identification (Fidler et al., 2005).

Frith's model (1985) is the classic and well-known model of reading development, and originally described three stages, the logographic, alphabetic and orthographic stage. In this model, learning to read necessarily evolves from one stage to another, first the visually oriented, but not analytical, logographic stage, then the alphabetic stage with an emphasis on

grapheme–phoneme allocation – sometimes also called the 'phonological route' (e.g., Roch & Jarrold, 2008), and finally the orthographic stage, also called 'visual route', with increasing fluidity in reading, letter groupings and word structure. However, there has been some discussion about the necessity of the logographic stage (e.g., Ehri & Wilce, 1985; Masonheimer, Drum, & Ehri, 1984; see Ratz & Lenhard, 2013, for this discussion).

The present study investigates how many students with DS are able to read, and at which reading stage according to Firth's model they do this, and thus is able to describe reading prevalences for students with DS for the first time. Other than samples from Great Britain (e.g., Byrne et al., 2002; Turner et al., 2008), the students in this sample are located exclusively in special education schools for ID.

Correlations are made regarding gender, age, intensity of ID and family affluence. The group of students with DS is then compared to students with ID due to mixed etiologies (''non-DS'') in subgroups matched in grades of ID according to ICD-10. The aim is to express differentiated statements about the structure of the heterogeneity of students with DS, and to discuss these with regard to the theoretical and empirical knowledge about DS. Hypothetically, it is supposed that students with DS show a specific profile in their achievement in reading due to their very specific skills and deficits in PA and different STM tasks described in various studies mentioned above. After all, PA and STM are very prominent predictors of reading.

2. Method

2.1. Participants

All 190 students with DS were part of a larger sample of 1629 students with ID as described in Ratz and Lenhard (2013) and in Dworschak, Kannewischer, Ratz, and Wagner (2012). This original sample was chosen in Bavaria, one of the most populated federal states in Germany with approximately 12.5 million inhabitants, by means of a stratified and randomized sampling regarding settlement structure, region and school type as layers. As a result of this sampling, a complete inventory had taken place in 20 schools (clusters), representing some 15% of all students with ID in Bavaria. Given these layers and the return rate of 56%, all data were weighted according to the original population of students with ID amongst these layers (Statistisches Bundesamt, 2011). There were no inclusive settings involved, as less than 2% existed in this region at the time of investigation in January 2010. This study refers to all participants of the original sample whose diagnosis ''Down syndrome'' was mentioned by the teachers, which have access to medical expert opinions. No further information as to the type of DS was available (trisomy 21, mosaicism or translocation). Altogether, 126 different diagnoses were mentioned, such as Fragile-X-syndrome (17 individuals), Angelman syndrome (12) or Williams syndrome (6), but no diagnosis was mentioned for 39% of the whole sample.

Of the total number of participants with DS of which age and gender answers were given ($n = 188$), 39.8% were female and 60.2% were male (Table 1) – a proportion which is due to the fact that males are more vulnerable to DS. The range of ages was 6–20 years, on average 12.9 years ($SD = 3.67$), the female students being slightly older ($M = 13.1$, $SD = 3.80$) than the male students ($M = 12.8$, $SD = 3.60$). The teachers were asked to rank the severity of ID of each student according to ICD-10 – they did this due to psychological tests, which each student in special schools for ID has run through, but no standard exists as to which test is to be conducted; and due to their specific schooling and experience (see below). They labeled less than one fifth (17.4%) as mild ID, the largest group by far as moderate ID (60.3%), 14.9% as severe ID and 5.6% as profound ID. This shows a different distribution to the entire group of students with ID, where roughly one third was ranked as mild ID, another third as moderate ID, and the last third as severe and profound ID (collapsed into one group) (Ratz & Lenhard, 2013). The intensity of

Table 1
Participants of the study.

	Down syndrome				Non-Down			
	n	%	Age Ø	*SD*	*n*	%	Age Ø	*SD*
Male	113	60.2	12.8	3.60	891	62.6	12.6	3.81
Female	75	39.8	13.1	3.80	533	37.4	13.4	3.75
Age 6–10	64	34.3	8.9	1.26	484	34.3	8.9	1.53
Age 11–15	74	39.6	13.5	1.76	557	39.5	13.6	1.79
Age ≥ 16	49	26.1	17.5	1.44	368	26.1	17.7	1.46
No ID	0	0.0	–	–	16	1.1	11.3	4.47
Mild ID	33	17.4	10.4	3.01	496	34.5	12.3	3.76
Moderate ID	114	60.3	13.6	3.66	466	32.3	13.5	3.58
Severe ID	28	14.9	12.7	3.40	231	16.0	13.3	3.81
Profound ID	10	5.6	12.4	2.84	200	13.9	13.9	3.95
FAS1	19	17.1	11.2	3.01	331	43.7	12.8	3.73
FAS2	56	51.9	12.9	3.67	305	40.3	13.5	3.63
FAS3	34	31.0	13.6	3.82	121	16.0	12.9	3.49
Total	190				1439			

ID, intellectual disability (ICD-10); FAS, Family Affluence Scale (Currie et al., 2008).

ID (five grades) in male and female students with DS is similar ($\chi^2(4) = 2.13$, $p = 0.51$).

The ages of the students were grouped according to German school stages, which are roughly similar to elementary, secondary and high school ("Grundschulstufe", "Hauptschulstufe" and "Berufsschulstufe"). The quota of students in these age groups is not consistent as each stage has a different length: the youngest group 4 years (6–10), the middle group five years (11–15) and the eldest group usually three years (16–18, though sometimes up to 21 years as some students are granted extra time in school). 34.3% of the sample attended the elementary school stage, 39.6% the secondary stage and 26.1% the high school classes. These school stages have different educational emphases and instructional contents. For some calculations the chronological age as a metric scale was applied.

2.2. Differences and similarities between participants with Down syndrome and other etiologies

Dividing the population of the original sample into a group of students with Down syndrome ($n = 190$) and a group with the remaining students ($n = 1439$) gives the opportunity to search for a specific profile in reading amongst students with DS. The structure of these two groups is similar in some aspects, and diverging in others (Table 1). The students with DS show almost no difference in the aspect of gender, 60.2% being male, compared with 62.6% males in the non-Down-group. Students with DS are slightly younger ($M = 12.9$; $SD = 3.67$) than students in the non-DS-group ($M = 13.1$; $SD = 3.79$). The age grouping is also almost identical, which appears when comparing the means (completely equal at $M = 1.92$[1]; $SD = 0.77$) as well as the shares in each group: Both groups of the students with DS were 6–10 years old (34.3%), 39.6% of the DS-group were11–15 years old (39.5% non-DS), and the over-16-year-olds were again identically old (26.1%). These aspects show that due to the stratified and weighted random sampling the sample is very well balanced.

On the other hand, the DS group differs significantly from the mixed group in the aspect of ID ($\chi^2(4) = 63.33$, $p < 0.01$). Almost two thirds of the students with DS are labeled as having a moderate ID by their teachers, mild and severe ID are quoted nearly equally at around 15%, none of them has no ID and 5.6% are found to have profound ID. The other group with mixed etiologies (non-Down) spreads far more evenly across the ID-groups, with a stress on mild ID (34.5%). If severe and profound ID are taken together, which makes some sense in regard to teachers' views, three approximately equal groups can be found within students with mixed etiologies.

The family background also varies between these groups. Students with DS grow up in far wealthier families than other students with ID. Typically developing children grow up in even wealthier families (FAS1: 7.8%, FAS2: 37.0%, FAS3: 55.2%; Dworschak & Ratz, 2012, 45).

2.3. Measures and procedure

Frith's developmental model of reading (1985) has been expanded by many researchers, including German authors. A common German model (Valtin, 1997) divides Frith's three steps into six, with the original structure still visible. This model was chosen for questioning, as it is well known to German teachers and the questions are very descriptive. With reading developing slower among students with ID, a model with more steps is obviously helpful in assessing the current reading stage. Table 2 shows a comparison of both models and the way the answers corresponded to Frith's steps.

All data were given by the individual teachers of the students. This decision was made because a large proportion of students with DS and ID cannot take part in standardized test routines, due to highly individual communication problems, intellectual problems and behavior problems. However, teachers in special education schools have a very detailed knowledge of their students as a result of small classes and a more embracing pedagogical view – this being closely related to the above mentioned problems. Above all, contact to parents and other guardians are often intensive even in higher classes. All teachers have a university degree in special education focusing on ID, comparable to a Master's degree, and a subsequent two-year teacher training, also specialized for students with ID. This university study as well as the teacher training embraces an intensive diagnostic instruction, authorizing them for diagnosis and conducting psychological tests – which belongs to their tasks as classroom teachers. Many have conducted psychological tests with their students, or can otherwise refer to these reports and therefore know their students extremely well. For all these reasons, a questionnaire was designed addressed to the teachers, one for each student, containing not only the reading questions in Table 2, but also relevant data such as family affluence, intensity of ID, diagnosis and behavior.

Family affluence was measured using the Family Affluence Scale (FAS), which was developed for the 'Health Behavior in School-Aged Children Study' (HBSC) of the WHO (Currie et al., 2008). FAS has been devised for children and uses four questions, the number of cars in the family, the number of family holidays in the last twelve months, students having an own room and the number of computers in the family. The answers add up to a maximum of seven scores, and are then divided into an ordinal scale of 1, 2 and 3, higher numbers showing more wealth in the family. In contrast to the original use of FAS, these questions were included in the questionnaire addressed to the teachers who were then able to ask students for information, if necessary and possible. As argued above, it is assumed that teachers in these schools know their students and their families well enough to answer these questions. Moreover, no other method can be found to assess these data about all students with ID.

[1] 1 = elementary (6–10); 2 = secondary (11–15); 3 = high school (16–21).

Table 2
Synopsis of reading stages in Frith's (1985) and Valtin's (1997) model.

Frith	Valtin Reading
	(Student does not read at all) 1. Pretends to read
1. Logographic	2. Guesses words
2. Alphabetic	3. Names phonemes 4. Reads letter by letter
3. Orthographic	5. Shows advanced reading abilities 6. Automatically identifies words

The questionnaire and the entire procedure were approved of by the Bavarian Federal Ministry for School Politics. The parents of each participating student had confirmed their consent to the questionnaire.

3. Results

3.1. Reading skills of students with DS

Students with DS display a rather specific spread of achieved reading skills across all age and ID groups. In the opinion of their teachers, half of these students read at an alphabetic level (49.4%; Table 3; Fig. 1), and nearly a quarter reads orthographically (22.8%). 20.2% do not read at all, whereas only 7.6% read at a logographic stage.

The differences in gender are worth looking at, as the sizes of both of these groups with DS reported above differ quite a bit and therefore questions arise. Both sexes show similar proportions of non-readers (Table 3). However, there are slight differences in the alphabetic and orthographic stages indicating that girls are further developed. Nonetheless, these differences show no significance in regard to reading in a 2×4 table (both sexes and four stages of reading) (χ^2 (3) = 3.46; $p = 0.32$). The slightly younger mean age of the boys further underlines the missing significance.

When grouping the students with DS according to age groups (elementary, secondary and high school), a development of reading skills from one age group to the other can be described (Table 3). These differences between the age groups, however, closely miss significance in reading (Spearman $r = 0.138$; $p = 0.054$). When using exact age as a metric scale, a clearer and significant result evolves (Spearman $r = 0.102$; $p = 0.000$).

The severity of ID is closely related to reading achievements (Table 3). The composition of the group of illiterate students is varied, and while half of the students with DS and severe ID (49.2%) can be described as illiterate, only few students with

Table 3
Prevalence rates of reading skills of students with DS ($n = 190$) and mixed etiologies (non-Down) ($n = 1439$).

	Down syndrome					Non-Down				
	n	Reading stages in %				*n*	Reading stages in %			
		Not at all	Logographic	Alphabetic	Orthographic		Not at all	Logographic	Alphabetic	Orthographic
Gender										
Male	113	20.4	9.1	51.8	18.8	876	31.2	6.4	30.0	32.4
Female	75	20.2	5.4	45.4	29.0	526	28.3	7.2	29.0	35.5
Age										
6–10	64	23.0	3.0	63.1	10.8	473	31.4	6.7	43.0	18.9
11–15	74	23.5	5.5	41.0	30.1	554	27.1	4.9	28.3	39.6
≥16	49	11.3	17.2	42.8	28.8	362	32.5	9.4	15.3	42.8
ID										
None	0	0	0	0	0	16	0	0	30.8	69.2
Mild	33	6.4	0	61.9	31.7	491	1.3	3.8	34.1	60.8
Moderate	114	8.9	10.9	53.2	27.1	462	16.0	9.4	43.6	31.0
Severe	28	49.2	6.8	41.5	2.4	229	68.6	13.1	13.4	4.9
Profound	10	100	0	0	0	189	99.6	0.4	0	0
FAS										
1(0–3)	19	31.5	7.0	31.9	29.6	325	19.3	3.8	35.4	41.4
2(4;5)	56	17.0	5.5	51.1	26.4	301	30.0	6.1	25.6	38.2
3(6;7)	34	18.9	5.0	47.9	28.2	121	30.9	6.0	32.4	30.6
Total	189	20.2	7.6	49.4	22.8	1419	30.5	6.7	29.6	33.2

ID, intellectual disability (ICD-10); FAS, Family Affluence Scale.

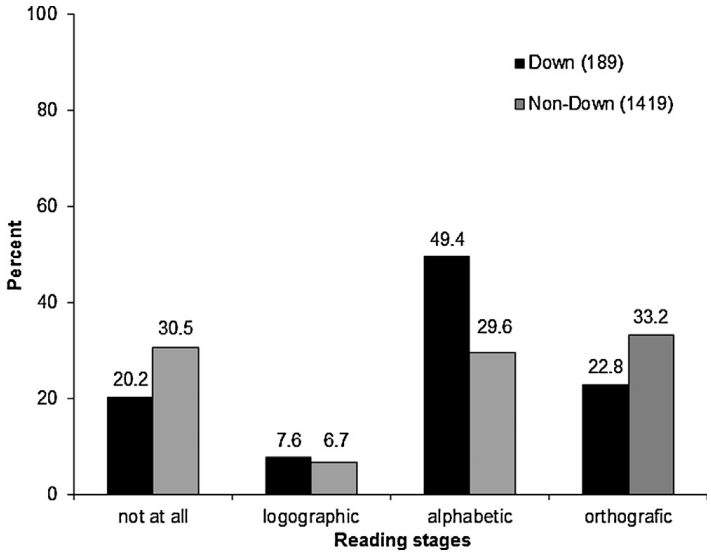

Fig. 1. Prevalence of reading stages: comparison of DS and non-DS-students (all ID-grades).

moderate (8.9%) or mild ID (6.4%) fall into this category. The same differences occur vice versa on the orthographic level: only 2.4% of students with severe ID were labeled orthographic readers, compared to 27.1% of those with moderate ID, and 31.7% with mild ID. There is a strong correlation between ID and reading (Spearman $r = -0.434$; $p < 0.01$).

Family affluence, as measured with the FAS (Currie et al., 2008) (Table 3) shows no bivariate correlation in regard to reading (Spearman $r = 0.083$; $p = 0.382$).

3.2. Comparison of Down syndrome with mixed etiologies (non-DS)

3.2.1. Reading stages in DS and non-DS in general

The first point of comparison is between all students with DS and all other students with ID attending special schools for ID in Bavaria. This general comparison corresponds to the way they appear proportionally in the actual classes and therefore influences the preparation for the classes. Descriptively, students with DS show a higher level of reading ($M = 2.75$, $SD = 1.03$) than all other students with ID ($M = 2.69$, $SD = 1.22$). An analysis of covariance (ANCOVA) with reading level as the dependent and 'DS–non-DS' as the independent variable, as well as severity of ID as the covariate, revealed that the biggest share of variance was explained by the covariate, $F(1, 1608) = 1742$; $p = 0.000$; $\eta^2 = 0.521$, whereas 'DS–non-DS' reveals a significant, albeit small main effect as well, $F(1, 1608) = 2.935$; $p = 0.043$; $\eta^2 = 0.002$).

Differences in the distribution of reading levels were analyzed post hoc via χ^2-tests. Achieved reading stages (0–3) differ between these two groups (DS and non-DS) (Table 3 and Fig. 1) ($\chi^2(3) = 32.36$, $p < 0.01$). 30.5% of the students with non-DS are "not reading at all", compared to only 20.2% of those with DS. These numbers are almost reversed in the last stage, the orthographic stage. According to their teachers, 22.8% of the DS students are able to read orthographically, compared with 33.2% in the non-DS group. The logographic stage is equally rarely mentioned (ca. 7%), which leaves the main difference in the alphabetic stage: Nearly half of the DS students (49.4%), but less than one third (29.6%) of the non-DS students read alphabetically.

There is not only a difference between the achieved reading stages as a whole. The results demonstrated an emphasis on the alphabetical level, and this is confirmed by a further calculation. When comparing the alphabetic stage with the three other stages taken together, Fisher's exact test shows significance ($p < 0.01$, $\chi^2(1) = 31.35$). This is statistical evidence for the emphasis on the alphabetical level amongst students with DS in general compared to students with other diagnoses with ID.

When considering the three age groups, the reading levels of DS and non-DS students progress from the 6–10 year-old group to the 11–15 year-old group. But the reading levels of both DS and non-DS-students are only slightly higher in the last age group. Within this group of over 16-year-olds there is a difference in regard to reading ability with more DS-students than non-DS-students reading at the logographic stage.

3.2.2. Differential comparison of reading development

The finding above, the emphasis on the alphabetic level in the reading development of students with DS, is a hypothesis, and attempting to prove a specific profile of reading development amongst students with DS requires parallelizing them as far as possible, as the two groups differ in some aspects, as reported above. As the reading development is mainly correlated to the severity of ID (see above; see also Ratz & Lenhard, 2013), further parallelizing efforts should take place in regard to the ID groups. Hardly any students with or without DS learn to read when their ID is profound, therefore this group was excluded from comparison, leaving the groups of severe, moderate and mild ID. As the sample was chosen randomly amongst clusters (whole schools) and weighted to the layers of settlement structure, school type and political region (see Section 2), and the

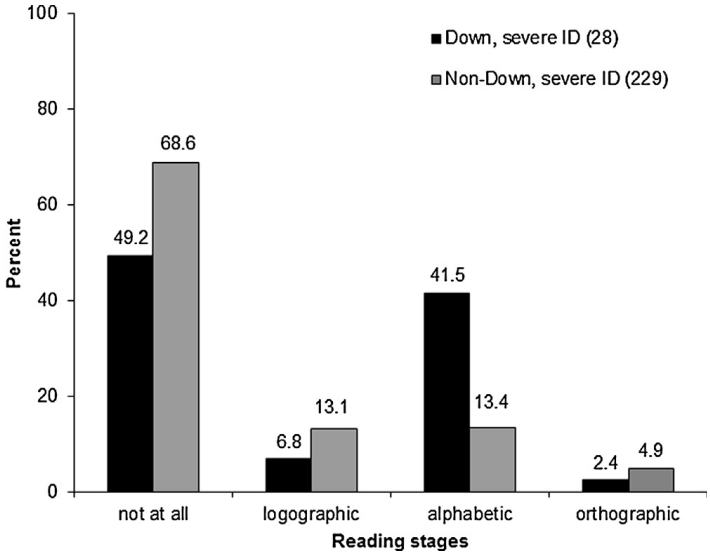

Fig. 2. Prevalence of reading stages: comparison of DS and non-DS-students (only severe ID).

weighting was active during all computing processes, DS and non-DS groups were parallelized according to these aspects as well. The age grouping of both groups was also very even (Tables 1 and 3).

3.2.3. Severe ID-group

In fact, the reading in each of the three ID-groups shows these differences in the role of the alphabetic level, too. In the severe ID group (Fig. 2), the largest number of students did not read at all, but there were noticeable differences: over a third of the students with mixed etiologies (68.6%) versus half of the students with DS (49.2%). While hardly any of these students with severe ID read at an orthographic level, there is a very specific difference on the alphabetic stage: 41.5% of the students with DS read at this level, whereas only 13.4% of the non-DS students with severe ID do. Students with DS are shown to be further ahead in reading with 1.97 in the mean ($SD = 1.02$) versus 1.55 in the non-DS-group ($SD = 0.90$). The distribution of the stages amongst both groups differs ($\chi^2(3) = 14.47$, $p < 0.01$). The emphasis on the alphabetic stage compared to all of the other stages is repeated in this parallelized group according to Fisher's exact test ($p < 0.01$, $\chi^2(1) = 15.63$).

3.2.4. Moderate ID-group

The students with moderate ID seem to be distributed more equally (Fig. 3), and the majority of students in both groups already read either at an alphabetic or orthographic stage. But the emphasis on the alphabetic stage amongst students with DS is also evident in this group with 53.2% of them reading at this level, compared to 43.6% in the mixed group. The differences between both groups are minor ($\chi^2(3) = 5.86$, $p = 0.12$), but when comparing the alphabetic stage with the other stages, Fisher's exact test once again shows an emphasis on the alphabetic stage ($p = 0.03$, $\chi^2(1) = 3.91$).

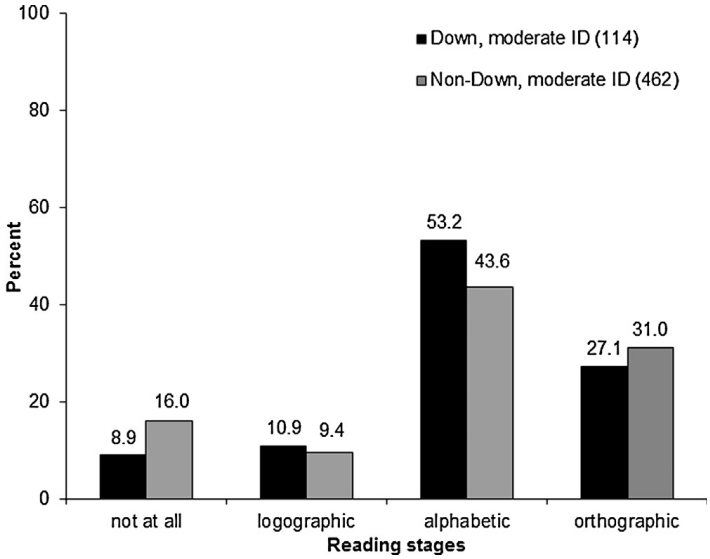

Fig. 3. Prevalence of reading stages: comparison of DS and non-DS-students (only moderate ID).

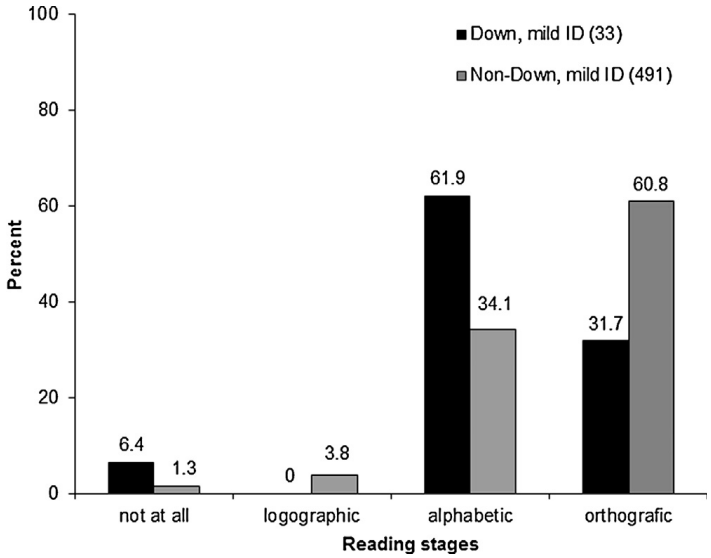

Fig. 4. Prevalence of reading stages: comparison of DS and non-DS-students (only mild ID).

3.2.5. Mild ID-group

This pattern continues when looking at students with mild ID (Fig. 4) ($\chi^2(3) = 17.45$, $p < 0.01$). 61.9% of the students with DS still remain at the alphabetic stage, compared to only 34.1% of those with mixed etiologies (non-DS). At an orthographic level of reading the quota is nearly opposite: only 31.7% of students with DS reach this level, compared to 60.8% of non-DS-students. When comparing the alphabetic stage with the other stages, students with DS and mild ID still show a prominent emphasis on the alphabetic stage (Fisher's exact test $p < 0.01$, $\chi^2(1) = 9.82$).

4. Discussion

The aim of the present study was to describe the level of reading skills of students with DS throughout their school years (aged 6–20 years), and then to compare them to students with ID deriving from all sorts of other diagnoses (non-DS), in order to detect a specific profile in the reading development of students with DS. The data of the students were given by their teachers using Valtin's (1997) developmental model of reading; the answers were then converted into the three stages of Frith's model (1985).

The group of students with DS as a whole differs in some aspects from the other students with ID in these schools, but not in others: The aspect of gender, with only one third of female students, is similar; this quota is specific for students in all schools with special educational needs in Germany (Statistisches Bundesamt, 2011). The distribution of age is also identical, this validating the sampling process. A difference between the group of students with DS and all other students with ID can be found in the severity of ID according to ICD-10. The students with mixed etiologies (non-DS) spread quite evenly across all groups (when severe and profound ID are combined into one group), while on the other hand nearly two thirds of the students with DS are described as moderate ID by their teachers, showing a strong emphasis on this ID range. A further difference between both groups can be seen in the family background as measured with FAS, which shows that, in the mean, students with DS come from more wealthy families as students with mixed etiologies. But they still do not reach family wealth of school aged children in general in Germany, and above all, the deviation is considerable.

The reading development of students with DS shows a strong emphasis on the alphabetic stage. This is noticeable when looking at the group as a whole, and also when comparing the whole group to all other students with ID as they appear in classroom, and it finally becomes evident when matching ID-groups are compared with one another.

The results of the students with DS offer more opportunities for interpretation than the results for students with other diagnoses for ID as more details of a DS development profile are available. As reported above, individuals with DS seem to have a specific profile of the short term memory (STM) (Frenkel & Bourdin, 2009; Jarrold & Baddeley, 2001; Kay-Raining Bird & Chapman, 1994). This profile shows difficulties with the verbal STM, and nearly normal visual STM when compared with nonverbal mental age, often also parallel to hearing impairments (Byrne et al., 2002). This knowledge corresponds very well to the findings of this study, as the ability to read alphabetically means that the concept of phoneme and grapheme allocation has been understood, and sounding out words grapheme by grapheme is beginning to take place. At this stage, verbal STM plays a vital role as the reader has to memorize the identified phonemes from the beginning of the word onwards, in order to put the meaning of the word together. When reading sentences, the previous words also have to be remembered. Difficulties with the verbal STM seem to culminate in a thorough barrier toward the orthographic level of reading. The results of this study show the impact of this specific profile of STM of students with DS on learning to read in comparison to students with ID and mixed etiologies.

This barrier between the alphabetic and the orthographic stage does not only affect students with higher reading abilities, which is particularly evident when comparing those students with mild ID (Fig. 4); students with DS in the severe ID-group also have an emphasis on the alphabetic stage, and – in contrast to the lag in the mild ID-group – now prove to be far ahead in reading (Fig. 2). A possible explanation for this result may be the other aspect of the specific STM profile of students with DS: Difficulties with the verbal STM had explained the barrier, whereas their nearly normal visual STM may help them to learn phoneme–grapheme allocation more easily, and this is a precondition for the alphabetic stage of reading.

How does this outcome affect reading instruction? Several aspects may be discussed. One of them is the way in which students with DS are taught to read. Some authors suggest teaching to read with sight words as a specific method for students with DS, e.g. Oelwein (1995) (Baylis & Snowling, 2012; Browder & Xin, 1998; Fidler et al., 2005; Roch & Jarrold, 2008). A strong visual STM enables students with DS to memorize pictures fairly easily. As sight words can actually be memorized as pictures, the result is that they have hardly any difficulties in learning a considerable amount of sight words. However, it must be kept in mind that teaching to read only with sight words does not lead to orthographic reading (e.g., Dehaene, 2009). This stage of reading only derives from a thorough insight in reading, containing a complete understanding of grapheme–phoneme allocation. From this point onwards, orthographic reading develops along with practice. The alphabetic stage cannot be skipped by teaching sight words, although trained readers in fact also read sight words – but only after having passed through the alphabetic stage. Recent evidence that phonics skills are highly relevant for developing full literacy in comparison with sight word teaching for students with severe developmental disabilities has been found by Browder et al. (2012) (see also Burgoyne et al., 2012 and Groen et al., 2006).

For the process of teaching students with DS, an impaired verbal STM must be considered. Koch (2008) has pointed out that a verbal three span task is sufficient for reading if one takes into account that phonemes can be grouped to syllables, thus reducing the amount of elements to be memorized. But this requires an appropriate method of teaching which trains the task of syllable-reading.

Taken together, the results of this study, which align well with their profile of STM found in other research, lead to the following recommendations: although a strong visual STM makes students with DS learn sight words easily, this is not a path to literacy. Practice in phonological awareness, learning phonics and sounding short words out is essential. The specific impairment in their verbal STM will presumably lead to difficulties when sounding out longer words, this has to be taken into account. Teaching these students to read by syllables seems a reasonable consequence, and requires offering word material with marked syllables such as bows beneath each syllable or syllables in different colors. Effects of these teaching efforts, however, are hypothetic and remain to be proved.

Another aspect that, however, turns out to be minor is the different sociocultural background of students with DS. According to the FAS measurement, their families are wealthier than those of non-DS students with ID, but still far less wealthy than typically developing school aged children in Germany. This can be described as a specific situation of students with DS, and in contrast to many other students with ID. It remains to be said that despite this profile amongst Down syndrome, there is still an enormous variance among individuals with DS deriving from diverging sociocultural backgrounds as well as genetic differences in each individual.

4.1. Study limitations

The three different types of DS (trisomy 21, mosaicism or translocation) were not taken into account in this study. As there is no reason for systematic influences, it is assumed they occur at random and in the same proportion as usual. The phonological awareness has also not been taken into account, which is an important predictor for reading.

The differences between reading in German and English are well-known (Landerl, Wimmer, & Frith, 1997; Seymour, Åro, & Erskine, 2003; Wimmer, Hartl, & Moser, 1990), and mainly bear on the logographic stage being less important in German. This results from a more shallow orthography in German, which seems to make it easier to learn to read. While the results of this study are not affected by this as it only considers German schools, these differences need to be kept in mind when comparing the results with other languages.

Future research may also attempt to improve assessment of academic achievements of students with ID. This includes teacher training on collecting data, as well as developing instruments, such as the Academic Attainments Index (AAI), which comprises three subscales covering reading, writing and numeracy (Sloper, Cunningham, Turner, & Knussen, 1990).

An important future research field is the consequence of these findings for teaching. As pointed out, sight or whole word reading is not appropriate for gaining a thorough insight in reading, and the outcome of learning to read by syllables for students with ID as suggested here has to be investigated further. The outcome of research on students with DS may also be exemplary for many other diagnoses for ID, such as Williams' syndrome, Fragile X and many other genetic syndromes. It seems likely that students with other syndromes also have a specific learning profile for reading and further research will be of interest to the development of teaching. Research on learning profiles will be relevant to many other learning areas or domains, such as language and numeracy.

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