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Development of Word Reading Fluency and Spelling in a Consistent Orthography: An 8-Year Follow-Up

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In a longitudinal study, development of word reading fluency and spelling were followed for almost 8 years. In a group of 115 students (65 girls, 50 boys) acquiring the phonologically transparent German orthography, prediction measures (letter knowledge, phonological short-term memory, phonological awareness, rapid automatized naming, and nonverbal IQ) were assessed at the beginning of Grade 1; reading fluency and spelling were tested at the end of Grade 1 as well as in Grades 4 and 8. Reading accuracy was close to ceiling in all reading assessments, such that reading fluency was not heavily influenced by differences in reading accuracy. High stability was observed for word reading fluency development. Of the dysfluent readers in Grade 1, 70% were still poor readers in Grade 8. For spelling, children who at the end of Grade 1 still had problems translating spoken words into phonologically plausible letter sequences developed problems with orthographic spelling later on. The strongest specific predictors were rapid automatized naming for reading fluency and phonological awareness for spelling. Word recognition speed was a relevant and highly stable indicator of reading skills and the only indicator that discriminated reading skill levels in consistent orthographies. Its long-term development was more strongly influenced by early naming speed than by phonological awareness.

Keywords: reading fluency, spelling, longitudinal assessment, long-term prediction of reading and spelling

Only recently, word reading fluency has moved from being a neglected aspect of reading to being a popular topic in the field of reading research. As Ehri (2002) stated,

> One of the great mysteries to challenge researchers is how people learn to read and comprehend text rapidly and with ease. . . . A large part of the explanation lies in how they learn to read individual words. Skilled readers are able to look at thousands of words and immediately recognize their meanings without any effort. (p. 7)

A longitudinal study with a sample of normally developing readers of German allowed us to follow the development of word reading fluency and also orthographic spelling skills over almost 8 years, from school entry through to Grade 8.

Most longitudinal studies with English-speaking children did not even include measures of reading fluency but reported development in word reading accuracy only (see Parrila, Aunola, Leskinen, Nurmi, & Kirby, 2005, for a review). In phonologically more transparent orthographies, however, word reading accuracy is often close to or at ceiling after only a few months of formal reading instruction (Cossu, Giuliotta, & Marshall, 1995; Oney & Goldman, 1984; Wimmer & Hummer, 1990), and word reading speed is the only word reading measure that differentiates between good and poor readers in higher grades.

There exist a few studies reporting longitudinal development of reading fluency in orthographies with consistent grapheme–phoneme correspondences. Bast and Reitsma (1998) followed the reading development of 235 Dutch children from kindergarten to the end of Grade 3. The first assessment of word reading fluency was carried out 3 months after the onset of formal reading instruction, with two further assessments during first grade, two assessments in second grade, and a final assessment toward the end of third grade. At each of the measurement points, children were given word lists, and the dependent variable was the number of words read correctly within a certain time limit (between 1 and 3 min). Unfortunately, Bast and Reitsma did not report reading accuracy separately from reading speed. Only for the later measurement points is it likely that accuracy among these readers of the consistent orthography of Dutch was high so that the reported measure can be interpreted as a pure measure of reading fluency. The finding of importance is that, with respect to reading fluency, the rank ordering of individuals was highly stable for the measurements after Grade 1, and individual differences in word recognition fluency even increased over time.

Parrila et al. (2005) recently reported a longitudinal assessment of a sample of 197 Finnish children's development of oral reading fluency (reading a short text as quickly as possible) from the

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beginning of Grade 1 until the end of Grade 2. This study also indicated high stability of reading fluency over four measurement points (two per school year), but, in contrast to Bast and Reitsma (1998), the authors did not find evidence that individual differences increased during the project period. Once again, it is problematic that Parrila et al. (2005) did not report reading accuracy separately from reading fluency, so that it is unclear whether these two measures were confounded. Parrila et al. (2005) also reported high stability in reading development for a sample of 198 Canadian children who were followed from Grade 1 up to Grade 5. However, this finding is not informative with respect to reading fluency development as—quite typical for studies with English-speaking children—the dependent measures only included measures of word reading accuracy but no measure of reading speed.

De Jong and van der Leij (2002) followed the reading fluency development of 141 Dutch children. They reported a correlation of .69 between word reading fluency (number of words read correctly in 1 min) at the end of Grade 1 and Grade 3, suggesting a high stability over the years. When the students were in Grade 6, de Jong and van der Leij (2003) retested specifically selected subgroups from their longitudinal sample. A group of dyslexic children was selected on the basis of their reading skills in Grade 3, when their level of word reading fluency was, on average, more than two standard deviations below the age norms. This strong deviation from the mean was still evident in Grade 6, confirming the high stability of word reading fluency. It is interesting that at the end of Grade 1, dyslexic children's word reading accuracy was high and not significantly different from that of a control group of children with age-adequate reading development. This finding indicates that the extremely low reading fluency that these children exhibited was not caused by lack of knowledge of the graphophonemic connections.

In an Austrian longitudinal study Klicpera and Schabmann (1993) documented 356 German-speaking children's reading development from Grade 2 to Grade 8. In the middle of Grade 2, children were assigned to five reading level groups on the basis of their reading fluency. The stability for the highest and lowest reading level groups in particular was very high. Only 2 children who were among the 5% of poorest readers in Grade 2 developed average reading skills in Grade 8, but 94% of this group still performed below Percentile 15. The children who had been assigned to the lowest reading level in Grade 2 exhibited a reading fluency in Grade 8 that was comparable to that of average readers in Grade 2. Thus, their reading speed development was about 6 years delayed. Nevertheless, word reading accuracy was high even among the poorest reading level group. Already in Grade 2 they read fewer than 20% of the presented words incorrectly. This is impressive, given the fact that reading was assessed under speed instruction. Without the emphasis on reading as fast as possible, accuracy might have been even higher. Obviously, there was not much room for further improvement in reading accuracy later on. In Grade 8, even the poor readers made errors on fewer than 10% of the presented words.

The current study followed children's literacy development over an even longer time period than any of the studies reported above, namely from school entry until the middle of Grade 8. This longitudinal assessment allowed us to test the stability of reading fluency development and also of orthographic spelling skills over three assessments (end of Grade 1, beginning of Grade 4, and middle of Grade 8). Furthermore, the design of the study also enabled us to assess the predictive power of standard psycholinguistic measures for the longitudinal development of reading fluency and spelling. The first assessment was carried out at the beginning of Grade 1, before the onset of formal reading instruction, and included measures of phonological processing (phonological awareness, phonological short-term memory), letter knowledge, and rapid automatized naming. It is important to note that the German/Austrian kindergarten system does not provide explicit reading preparation. During their preschool years, children are supposed to develop in the context of playing. Reading, spelling, and arithmetic are only introduced in first grade. This difference between the German and the Anglo-American preschool education systems became clearly evident in a direct comparison of the letter knowledge and phonological awareness of Austrian and U.S. kindergartners carried out by Mann and Wimmer (2002). Percentages of correctly named letters were above 90% for U.S. kindergartners but only around 30% for their Austrian age mates.

Findings of earlier phases of this longitudinal assessment were reported in Wimmer, Mayringer, and Landerl (2000, Study 2) and Wimmer and Mayringer (2002, Study 2). The main findings were that serious deficits in reading fluency and orthographic spelling were not strongly associated with each other and that they might have been based on different cognitive deficits. In Wimmer et al. (2000), we reported that those children who entered school with serious deficits in phonological awareness later on developed problems in orthographic spelling and irregular word reading but not in the domain of phonological decoding (i.e., nonword reading). Obviously, this is in striking contrast to findings with English-speaking children, for whom deficits in phonological awareness have been demonstrated to be closely associated with problems in phonological decoding (Vellutino, Fletcher, Snowling, & Scanlon, 2004) and for whom phonological decoding, in turn, is seen as a bottleneck to further reading acquisition (Perfetti, 1985). The combination of the highly consistent grapheme–phoneme correspondences of German orthography and a systematic phonics teaching approach seems to enable even children who enter school with low phonological skills to master the initial hurdle of phonological decoding. Only when the relationships between spoken and written language become more complex, as in irregular word reading or spelling, where German orthography is clearly less consistent than in the reading direction, do early phonological deficits seem to have a more persistent negative influence on children's literacy development.

While early phonological awareness deficits did not have a strong influence on children's later reading development, deficits in sequential naming speed, measured by a rapid automatized naming paradigm, did: Children who entered school with a serious naming speed deficit turned out to read both words and nonwords with strikingly low reading fluency in Grade 4. In addition, they showed problems in orthographic spelling.

In a second, retrospective analysis of the longitudinal data, Wimmer and Mayringer (2002) selected three deficit groups from the large normative sample of 301 children on the basis of their reading and spelling performance in Grade 4: A group of dysfluent readers who had age-adequate skills in orthographic spelling, a group of poor spellers with age-adequate reading fluency, and a group of students who were deficient in both reading fluency and orthographic spelling. It turned out that the dysfluent readers already showed marked problems in rapid automatized naming of objects at school entry. The poor spellers, conversely, typically started into their school career with a deficit in phonological awareness. The group with combined reading and spelling deficits showed problems in both cognitive domains when they entered school.

In summary, the findings suggest that, at least in the German context of a consistent orthography and a synthetic phonics teaching approach, reading development depends more strongly on adequate naming speed than on phonological awareness. Similar findings come from studies in Dutch (de Jong & van der Leij, 1999, 2002) and Italian (Di Filippo et al., 2005). This is plausible, as the main problem of poor readers in phonologically transparent orthographies is extremely low reading fluency, while reading accuracy is usually high (de Jong & van der Leij, 1999; Landerl, Wimmer, & Frith, 1997; Wimmer, 1993; Zoccolotti et al., 2005). The literacy skill that does depend on good phonological awareness is spelling rather than reading. However, note that it is not the component of phoneme segmentation in spelling that is predicted by phonological awareness. After only few months of formal instruction, German-speaking children are usually very well able to translate even complex phoneme sequences into phonologically plausible grapheme sequences (Wimmer & Landerl, 1997). However, such a systematic phoneme–grapheme translation is not sufficient to spell words orthographically correctly, because the consistency of phoneme–grapheme correspondences is much lower than the consistency of grapheme–phoneme correspondences. Quite often, there are two or three different possibilities to translate a certain phoneme into a phonologically adequate grapheme, but obviously only one of these possibilities is orthographically correct. A plausible explanation for why phonological awareness might be relevant for orthographic spelling is that the build-up of stable representations in orthographic memory requires phonological underpinning—that is, multiple and redundant associations between the letters and sounds of specific words (Ehri, 1992; Perfetti, 1992). Deficits in phonological awareness might be an indicator that phonological representations are not well enough specified to be accessible for the formation of such associations (Snowling, 2000).

Two main questions are addressed on the basis of the Grade 8 assessment: First, how stable was the development of reading fluency and orthographic spelling over the 8 years of the reported longitudinal study? The second question we want to address is to what extent the pattern of predictions reported for Grade 4 can be replicated in Grade 8. Predictor measures assessed at the beginning of Grade 1 were tests of letter knowledge, rapid automatized naming, phonological processing (awareness and short-term memory), and nonverbal IQ.

After Grade 4, all children change to different secondary schools in the Austrian school system, which made it impossible to keep track of all participants of the originally large sample of 356 children. Still, we did not want to miss the unique opportunity to get longitudinal information on children's literacy development by collecting data from as many children as possible before some of them left school after the 9 years of obligatory schooling in the Austrian school system.

Method

Sample and Procedures

In Grade 1, a large sample of 356 children, from eight schools and 23 classrooms, was tested. In Grade 4, 296 children of the original sample could be retested; 60 children had moved or were not in school on the day of testing. Almost 8 years after the first assessment, we tried to contact all students who had participated in Grade 4. For 83 students, no addresses were available, so that they could not be invited to participate. From those who received our letter of invitation to participate in a further assessment at the Department of Psychology, 98 did not respond or declined. The number of students who agreed to participate was 115 (65 girls and 50 boys). All students attended Grade 8. Mean ages at the various assessment points were 6.9 years at the beginning of Grade 1, 7.5 years at the end of Grade 1, 10.2 years in Grade 4, and 14.3 years in Grade 8 ($SD = 0.5$ years at all assessment points). Only data from children who participated in all assessments are reported in this article.

In the first 2 months after children entered school, we assessed phonological processing (awareness and short-term memory) and rapid automatized naming. Nonverbal IQ was measured in the second test session at the end of Grade 1. Reading and spelling skills were assessed at the end of Grade 1, beginning of Grade 4, and middle of Grade 8. All first-grade and fourth-grade assessments were carried out in the school; only the last assessment in Grade 8 took place in our lab. Apart from the spelling tests in Grade 4 and Grade 8, which were administered groupwise, all testing was done individually. Individual testing was carried out in a separate room and lasted between 30 and 40 min at each measurement point. All testing was carried out by trained master's and doctoral students.

Measures

Beginning of Grade 1

Letter knowledge. Children were presented with the most frequent 19 uppercase letters and were asked to name them. Either letter name or letter sound counted as a correct response.

Rapid automatized naming. Four object pictures (car, ball, dog, mouse) were introduced, and the child was asked to name them as rapidly as possible. A further practice trial with two lines of these pictures familiarized children with the demands of rapid naming. The test page consisted of eight lines, with 4 pictures on each line (total of 32 pictures), with the pictures in varying order in each line. After the first four lines, the experimenter recorded the response time without interrupting the child. At the end of the eight lines, response time was recorded again. The correlation between the first and second halves of the naming speed task was .61.

Phonological short-term memory. Children were asked to repeat 16 sets of (C)CVC nonsense syllables. Eight items consisted of two syllables (e.g., *tes–bof*), the next eight syllables consisted of three syllables (e.g., *gat–fos–hap*). The correlation between two- and three-syllabic items was $r(295) = .48$, $p < .001$.

Phonological awareness. Manipulations on the phoneme level are usually rather difficult for Austrian 6-year-olds, who receive no reading preparation in kindergarten. In earlier studies, we found floor effects for traditional phoneme awareness tasks such as phoneme deletion or phoneme substitution (Mann & Wimmer, 2002; Wimmer, Landerl, Linortner, & Hummer, 1991). To design a task with an acceptable level of difficulty, we developed a paradigm in which children had to imitate a phoneme segmentation modeled by the experimenter. The experimenter explained that words can be divided into smaller parts and demonstrated this with *fee*: /f/-/e:/. Children were instructed to imitate the segmentation procedure modeled by the experimenter. After the child had repeated the practice item correctly, the experimenter presented six CV words and six CVC words. For each item, the experimenter said first the word and then the constituent phonemes, and children had to imitate her by producing both the word and the segmented sounds. The idea was that a child who did not understand the relation between the word and its segments would find the task difficult, while awareness of the sound structure of words would make it easier to imitate the experimenter correctly. This measure bears similarity with the phonological memory task, in which nonsense syllables instead of phoneme sounds had to be repeated. However, the correlation between the phoneme task and the nonsense syllable task was only moderate (.30, $p = .001$), so that only 9% of the variance of our phonological awareness measure could be explained by phonological memory capacity. The clearly higher correlation with letter knowledge (.57, $p < .001$) suggests that children profited from knowledge of letter–sound associations. The correlation between letter knowledge and phonological memory was also only moderate (.20, $p < .05$), indicating that children's letter knowledge was not only based on rote memory of the letter names. The reliability of the task was satisfactory. The correlation between CV and CVC items was .58 ($p < .001$). For a subsample of 40 randomly selected children, we carried out an item-based analysis. Internal consistency turned out to be high ($\alpha = .80$).

End of Grade 1

Nonverbal intelligence. To assess children's nonverbal cognitive skills, we gave them Raven's Coloured Progressive Matrices (Schmidtke, Schaller, & Becker, 1978).

Reading fluency. Children were given two word and two nonword lists. One word list consisted of 9 one- and two-syllabic high-frequency concrete nouns; the other one consisted of 9 one-syllabic high-frequency function words. The task was introduced by a practice sheet with six words. One of the nonword lists consisted of 9 two-syllabic nonwords without consonant clusters; the other list included 9 one-syllabic nonwords with consonant clusters in onset and/or coda position. The nonword reading paradigm was also introduced by a practice list consisting of six nonwords. Children were instructed to read "as quickly as possible, without making mistakes." Both number of reading errors and reading time for each list were recorded: Reliability of the fluency tasks (syllables per minute) is evident from the high correlations among the four measures (ranging from .83 to .92, ps $< .001$).

Spelling. Eleven high-frequency words were dictated to each child individually. After only 8 months of formal instruction, it did not seem appropriate to expect children to spell the words orthographically correctly. We rather wanted to know how well children would be able to translate the phoneme code into a phonologically plausible letter sequence. Thus, we scored whether a spelling was phonologically adequate in the sense that each sound in the word pronunciation was translated by an acceptable grapheme. To make phoneme segmentation more difficult, we ensured that each of the words included a consonant cluster in the word onset position, and three words included a second consonant cluster in the word-final position.

Grade 4

Reading fluency. Children were asked to read aloud a short story and two word lists from a standardized reading test battery (Landerl, Wimmer, & Moser, 1997). The text consisted of 57 words and was of simple content, so that reading time would not be affected by comprehension difficulties. The word lists each consisted of 11 complex compound words typical for German language (e.g., *Fruchtsaft*—fruit juice, *Geburtstagskuchen*—birthday cake). Children were instructed to read "as quickly as possible, without making mistakes." The correlation between reading fluency for the short text and the compound word lists was .88 ($p < .001$). The test handbook reports satisfactory reliability (parallel test method) for both compound words (.93) and text (.90).

Spelling. Children had to fill 35 dictated words into sentence frames clarifying the word meaning. The words were specifically selected so that a simple phoneme–grapheme translation would not be sufficient to spell the words orthographically correctly. Each word included at least one orthographic marker typical for German orthography. The full sentence was read out by the experimenter, then the word to be spelled was repeated. Finally, the full sentence was repeated once more. Half of the sentences were taken from a standardized spelling test (Landerl, Wimmer, & Moser, 1997) with adequate reliability (.74); no reliability data were available for the current sample.

Grade 8

Reading fluency. Reading fluency was assessed with two text reading paradigms. All texts were short and simple, so that good comprehension was ensured. The main criterion was the speed with which the texts could be read. First, participants were asked to read two short texts out loud. Text 1 was about the development of the Internet and consisted of 73 words and 177 syllables. Text 2 was about a new electric fence for cattle and consisted of 92 words and 156 syllables. Both errors and reading times were recorded. The correlation for reading time for the two texts was .85 ($p < .001$). Asking participants to read aloud is an efficient way to assess both reading accuracy and reading speed; however, reading aloud is a rather untypical reading activity for older readers. The more natural reading activity is silent reading, which was also assessed. Three different texts, consisting of 260 words and 536 syllables altogether, were presented on a computer screen. To cover the probably widespread interests of our participants, we ensured that the texts were about very different topics (the Chinese Wall, legal restrictions for selling certain alcoholic drinks to adolescents, and an incident in which a hawk attacked a dog). Two texts were selected from daily newspapers, and one text came from a science book for adolescents. Participants were asked to read each text silently as quickly as possible and to press the space bar, triggering the response time measurement, when finished. The procedure was introduced by a short practice text consisting of 57 words. To ensure that participants read the texts carefully, the experimenter asked a short question after each text. Although they had not been informed about the comprehension questions before reading the text, all participants answered these questions correctly. These correct answers show that participants attended to the text and that the texts were of a rather simple comprehension level for that age group. It is therefore unlikely that reading fluency was strongly influenced by comprehension difficulties. Obviously, word reading accuracy could not be measured for this paradigm; only reading time was recorded. Correlations between the texts ranged from .88 to .91 ($ps < .001$).

Spelling. A standardized classroom test (Kersting & Althoff, 2004) was given in which students had to supply 68 dictated words or phrases to a cloze text. Each sentence was read out loud by the experimenter, and the word to be spelled was repeated. The test handbook reports high internal consistency (Cronbach's $\alpha = .93$).

Results

Attrition

Table 1 presents the means and standard deviations for the prediction measures separately for those 115 children who still participated in the study in Grade 8 and those 241 children who declined to participate in Grade 8. For letter knowledge, rapid automatized naming, phonological short-term memory, and nonverbal IQ, no statistical differences were found. On the phonological awareness measure, those children who dropped out of the study later on performed significantly lower than those who still participated in Grade 8, $t(352) = 2.68$, $p = .008$. Note, however, that the difference between the two groups was only 9%, which is small in relation to the standard deviation of 29%. We also compared Grade 4 performance for those 115 children who participated in all assessments and those 180 children who still participated in Grade 4 but not later on: No difference was found for word reading fluency (Grade 8 participants: $M = 174$ syllables/min, $SD = 47$; Grade 8 nonparticipants: $M = 164$ syllables/min, $SD = 47$), $t(293) = 1.76$, *ns.* Only with respect to spelling was there a rather small but, because of the large sample size, nevertheless significant difference: Children who dropped out of the study later on spelled 71% of the dictated words correctly, while those who participated in Grade 8 produced 75% correct spellings, $t(293) = 2.1$, $p = .04$.

Table 1
Descriptive Statistics of Prediction Measures for Children Who Participated in Grade 8 and Those Who Dropped Out of the Study

	Participants (n = 115)		Nonparticipants (n = 241)	
Prediction measure	*M*	*SD*	*M*	*SD*
Letter knowledge (% correct)	60.4	30.7	54.6	27.9
Phonological awareness (% correct)	60.5	28.5	51.6	29.4
Phonological short-term memory (% correct)	56.7	29.7	55.7	30.0
RAN (words/min)	56.1	12.1	54.8	11.1
Nonverbal IQ	117.0	12.5	115.5	12.4

Note. RAN = rapid automatized naming.

Development of Reading Accuracy

The upper section of Table 2 presents the accuracy measures for reading for the end of Grade 1, Grade 4, and Grade 8. It is evident that after only 1 year of formal reading instruction, children showed high accuracy for both words and nonwords. Actually, 51% and 33% of the children read the word and nonword lists without errors. Only 4 children (4% of the sample) read fewer than 80% of the words correctly, and only 12 children (10%) read fewer than 80% of the nonwords correctly. The minimum accuracy scores of 72% and 61% correct indicate that none of the young readers showed serious problems with phonological decoding. Although individual children certainly still needed more practice, all children showed good competence in translating grapheme sequences into word or nonword pronunciations; thus, they had good knowledge of the alphabetic mapping system. For the interpretation of all accuracy scores presented in Table 2, it must be noted that all reading tasks were given under time pressure. Children were instructed to "read as fast as you can, without making mistakes." It can be assumed that accuracy scores would be even higher if the instruction had been to read as carefully as possible.

Development of Reading Fluency

For each grade level, we computed scores of number of syllables read per minute. Because reading accuracy was high in all assessments, it was not necessary to correct the reading fluency scores for number of errors, and the scores were not confounded with reading accuracy. In Grade 1, separate scores were computed for the two word reading lists and the two nonword reading lists. In Grade 4, the short text and the two word lists were combined for this measure. In Grade 8, separate scores were computed for reading aloud and reading silently. The descriptive statistics for these combined fluency measures are presented in the middle section of Table 2. It is not surprising that reading fluency increased dramatically over the 8 years of the study. In Grade 1, there was a very high correlation ($r = .91$, $p < .001$) between reading fluency for words and nonwords, indicating that children were using a strategy of phonological decoding for words as well as nonwords. However, Table 2 shows that, even at that early point in reading development, children were clearly better at reading words compared to nonwords, $t(114) = 14.9$, $p < .001$. Another important observation is the enormous variability of the fluency measures that was evident in all grade levels. In Grade 8, silent reading was clearly faster than reading aloud. The correlation between reading aloud and silent reading was substantial ($r = .71$, $p < .001$).

Development of Spelling Skills

The important finding here is that after only 1 year of formal instruction, children were highly accurate in translating word pronunciations into grapheme sequences. The lower section of Table 2 shows that in Grade 4 children spelled a larger percentage of the dictated words correctly than in Grade 8. This was due to the higher degree of difficulty of the word material used in the Grade 8 test. Kolmogorov–Smirnov tests showed that scores on both the Grade 4 and the Grade 8 spelling measures were normally distributed ($Zs = 1.1$ and 0.9, respectively, $ps > .1$). The Grade 8 measure was a standardized spelling test, which allowed us to

Table 2
Descriptive Statistics of Reading and Spelling Measures in Grades 1, 4, and 8

Measure	*M*	*SD*	Min	Max
Reading accuracy (% correct)				
End of Grade 1				
Words	95.4	6.2	72.0	100.0
Nonwords	92.2	8.8	61.0	100.0
Grade 4				
Compound words	96.9	4.9	73.0	100.0
Text	97.9	3.9	82.0	100.0
Grade 8				
Reading aloud	96.7	3.6	68.0	100.0
Word reading fluency (syllables per minute)				
End of Grade 1				
Words	71.9	34.6	18.6	175.6
Nonwords	46.8	20.5	11.2	137.3
Grade 4	174.5	47.5	59.0	285.4
Grade 8				
Reading aloud	267.2	50.7	45.0	396.4
Silent reading	486.8	158.3	64.7	984.9
Spelling (% correct)				
End of Grade 1				
(phonologically adequate)	93.4	10.9	36.4	100.0
Grade 4	75.3	16.1	22.9	100.0
Grade 8	53.7	19.0	0.0	97.1

compare our sample with the norming sample. The mean performance of the current sample corresponded to the 54th percentile.

Stability of Reading Fluency and Spelling From Grade 1 to Grade 8

The second and third sections of Table 3 inform on the stability of the differences in reading fluency and spelling. In spite of the long time periods between the assessments, high correlations could be observed for word reading fluency. Even the correlations between reading fluency in Grade 1 and Grade 8, with an interval of almost 7 years, were around .60 The correlations for reading aloud and reading silently in Grade 8 were almost identical. The correlation between phonological spelling in Grade 1 and orthographic spelling in Grade 1 was also substantial and close to .50. The correlation between orthographic spelling in Grade 4 and Grade 8 was once again high.

Figure 1 examines the stability of reading fluency in more detail by plotting word reading fluency in Grade 1 against word reading fluency (for reading aloud) in Grade 8. Almost all of the 11 children who performed more than one standard deviation below the group mean in Grade 1 were still more than one standard deviation below the mean in Grade 8, which indicates high stability for deficits in reading fluency. Only 1 of the group of novice poor readers showed a Grade 8 reading fluency score that was actually slightly above average; 2 further students moved to the low average range. However, children who were already reading fluently in Grade 1 (more than one standard deviation above the group mean) without exception developed at least average reading skills later on. Thus, they had a very low risk of developing reading problems over the following years. The same scatterplot was also inspected for silent reading in Grade 8, and the findings were highly similar. We also inspected the scatterplots for reading fluency in Grades 1 and 4 and in Grades 4 and 8, and the stability was similarly high.

In an analogous scatterplot, we inspected whether early phonological spelling—that is, systematic phoneme–grapheme translation—is a precursor of later orthographic spelling skills. In Figure 2, phonological spelling skills in Grade 1 are plotted against orthographic spelling skills in Grade 8. In the phonological spelling task in Grade 1, 68 children—that is, almost 70% of the sample—performed at ceiling (no spelling errors or one error). The interesting finding here is that most of the 15 children who had problems with phonological spelling at the end of Grade 1 and performed more than one standard deviation below the group mean developed below average orthographic spelling skills later on. Only 3 of these students showed orthographic spelling skills in the low average range in Grade 8.

Table 3
Correlations Among Predictor Measures (Grade 1) and Reading Fluency and Spelling Measures (Grades 1, 4, and 8)

Measure	2	3	4	5	6	7	8	9	10	11	12
Grade 1 predictor measure											
1. Nonverbal IQ	.14	.15	.15	.09	.14	.23*	.32**	.30**	.31**	.30**	.43***
2. Letter knowledge	—	.57***	.20*	.39**	.40***	.43***	.32***	.35***	.25**	.47***	.47***
3. Phonemic awareness		—	.30**	.33***	.41***	.36***	.31**	.28**	.21*	.51***	.48***
4. Phonemic STM			—	.09	−.05	.02	.02	.00	.18	.23*	.28**
5. RAN				—	.45***	.46***	.34***	.34**	.31**	.35***	.32***
Reading fluency											
6. Grade 1					—	.69***	.59***	.64***	.35***	.52***	.52***
7. Grade 4						—	.81***	.77***	.40***	.63***	.69***
8. Grade 8: aloud							—	.71***	.48***	.59***	.64***
9. Grade 8: silent								—	.43***	.58***	.61***
Spelling											
10. Grade 1									—	.44***	.47***
11. Grade 4										—	.77***
12. Grade 8											—

Note. STM = short-term memory; RAN = rapid automatized naming.
* $p < .05$. ** $p < .01$. *** $p < .001$.

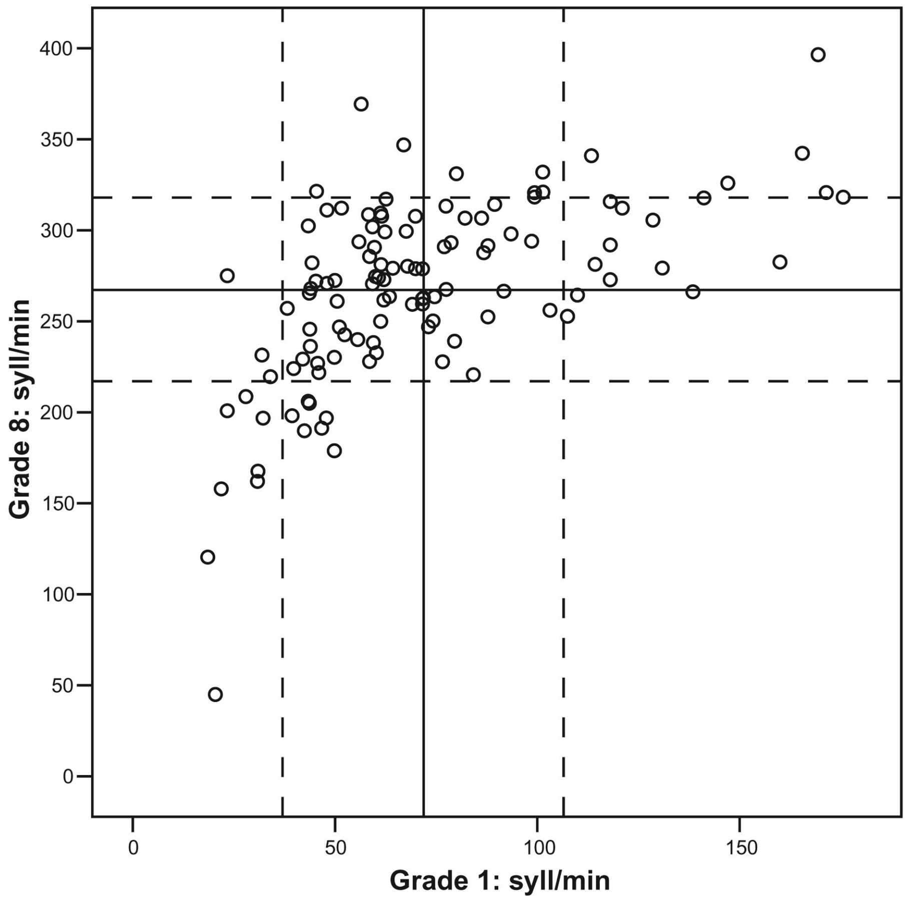

Figure 1. Scatterplot for reading fluency (syllables per minute) in Grades 1 and 8 (full reference lines represent the mean scores; dotted reference lines represent ±1 *SD*).

Prediction of Reading Fluency and Orthographic Spelling

The first section of Table 2 presents the correlations among the prediction measures and between these measures and the later reading fluency and spelling measures. Of interest is that nonverbal IQ was not associated with any of the other prediction measures but showed low but significant associations with reading fluency (not Grade 1) and also with all spelling measures. As already mentioned, early letter knowledge was substantially associated with phonological awareness and also with all other verbal predictor measures. Both letter knowledge and phonological awareness were associated with all reading fluency and spelling measures, and this was also the case for the rapid automatized naming measure. It is interesting that the phonological short-term memory measure was not associated with any of the reading fluency and spelling measures except for spelling in Grade 8.

To determine the specific contribution of rapid automatized naming and phonological processing (awareness and short-term memory) for the later literacy skills, we conducted two hierarchical linear regression analyses involving three steps each for each measure of reading fluency (Grades 1, 4, and 8) and orthographic spelling (Grades 4 and 8). Phonological spelling at the end of Grade 1 was not considered as a dependent measure because of the obvious ceiling effect in children's performance. In both analyses, nonverbal IQ and letter knowledge entered the regression equation in the first step. Rapid automatized naming and phonological processing (awareness and short-term memory) entered the equation in either the second or the third step: In one of the analyses, rapid automatized naming entered the equation in the second step and phonological processing (awareness and short-term memory) entered in the third; the order of steps was reversed for the other analysis. Phonological awareness and phonological short-term memory were entered together, as our phonological awareness measure was obviously influenced by phonological memory. With these regression analyses, we hoped to determine whether each one of the predictor skills contributed variance to performance on the dependent measure that was not already accounted for by the other.

As can be seen from Tables 4 and 5, rapid automatized naming contributed independent variance to reading fluency in all grade levels. The phonological measures contributed significantly to word reading fluency in Grade 1 only, as well as to the spelling measures in Grades 4 and 8, but they were no longer predictive for the later assessments of reading fluency in Grades 4 and 8. In summary, these regression analyses indicate that the phonological measures (phonological awareness and phonological short-term memory) accounted for significant variance for early reading fluency (Grade 1) as well as for orthographic spelling, even if the

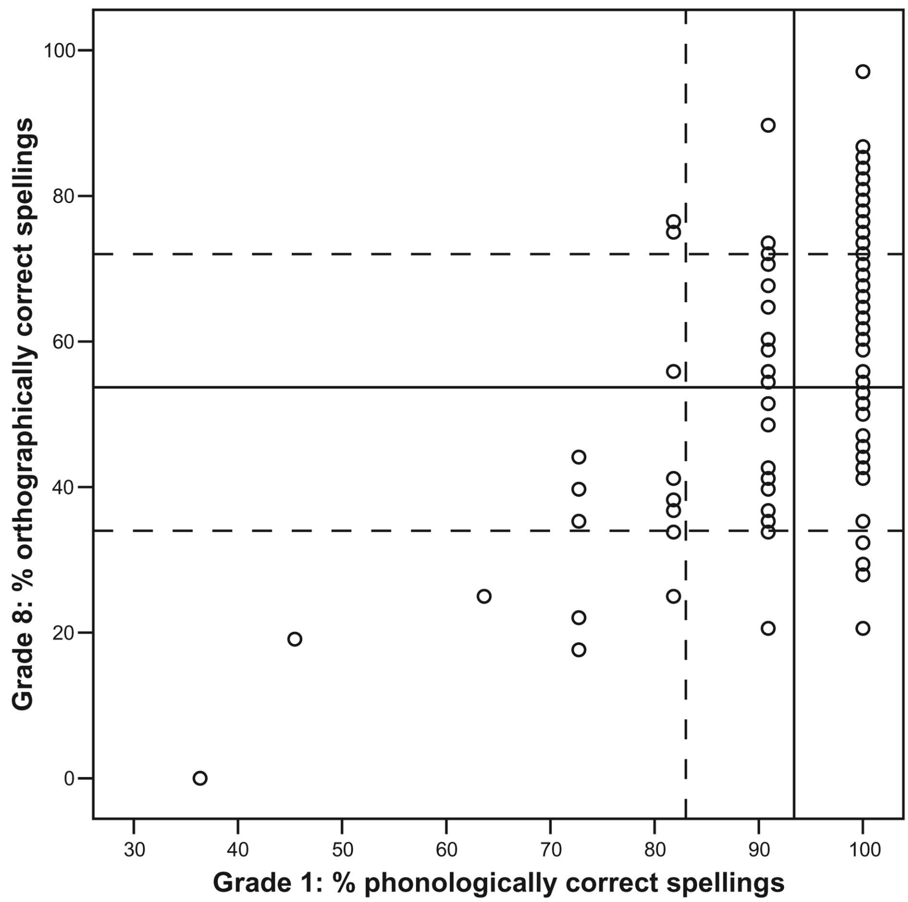

Figure 2. Scatterplot for phonological spelling in Grade 1 and orthographic spelling in Grade 8 (full reference lines represent the mean scores; dotted reference lines represent ±1 *SD*).

variance contributed by rapid automatized naming was already accounted for. Early rapid automatized naming, conversely, was a significant and consistent predictor of reading fluency at all measurement points.

Discussion

In line with earlier studies on the longitudinal development of reading fluency in consistent orthographies, we found a very high stability of reading fluency development over almost 8 years. This stability was evident from the strong correlations between the reading fluency measures in Grades 1, 4, and 8 and from the scatterplot presented in Figure 1. Fully 70% of the children who showed exceptionally slow and laborious reading (more than one standard deviation below the group mean) at the end of Grade 1 still were among the poorest readers of the current sample almost 8 years later. Only 3 children of the very poor first graders managed to develop at least (low) average reading skills later on. Not a single student of this group became an above average reader. Note that at the end of first grade, even the poor readers were well able to carry out the process of phonological decoding. Reading accuracy for words was high: Even the poorest readers were able to decode at least 60% of the nonwords correctly, and errors typically consisted of misreadings of only one letter. It is highly likely that reading accuracy would have been even higher if the reading tasks had been presented without time pressure. The same word and nonword reading lists were previously used in a European cross-linguistic comparison of reading accuracy at the end of Grade 1 (Seymour, Aro, & Erskine, 2003). In this study, reading material matched for length, frequency, and syllable structure was given to children in 13 different orthographies. Apart from the Scottish and Danish groups (both phonologically rather opaque orthographies), all first-grade samples were at or close to ceiling for both words and nonwords, which confirms that reading accuracy development proceeds rapidly in orthographies with consistent grapheme–phoneme correspondences. The high accuracy in the current sample is actually a methodological advantage, as reading fluency development can be examined independently of accuracy problems.

Similar findings of high reading accuracy in association with a high stability of reading fluency were reported by Klicpera and Schabmann (1993) for another German-speaking sample and by de Jong and van der Leij (2002, 2003) for a Dutch sample. It is often assumed that deficits in word recognition are ultimately due to a delay in the acquisition of phonological decoding skills. Such a delay would prevent children from applying a so-called self-teaching mechanism (Share, 1995) by which unknown words are

Table 4
Summary of Hierarchical Regression Analyses for Variables Predicting Word Reading Fluency in the Different Grade Levels

									Grade 8							
	Grade 1				Grade 4				Aloud				Silent			
Variable	R^2	ΔR^2	ΔF	β	R^2	ΔR^2	ΔF	β	R^2	ΔR^2	ΔF	β	R^2	ΔR^2	ΔF	β
Model 1																
Step 1	.15	.15	9.96***		.21	.21	15.05***		.18	.18	12.01***		.19	.19	12.79***	
Nonverbal IQ				.10				.17*				.27**				.26**
Letter knowledge				.14				.22*				.13				.20
Step 2	.23	.08	5.36**		.24	.03	2.17		.21	.03	2.17		.21	.02	1.65	
Phonemic awareness				.24*				.13				.16				.10
Phonemic STM				−.21*				−.12				−.12				−.13
Step 3	.30	.08	12.47**		.33	.09	14.41***		.25	.04	5.80*		.25	.04	5.67*	
RAN				.31**				.33***				.22*				.22*
Model 2																
Step 2	.25	.10	14.03***		.31	.10	15.98***		.22	.05	6.91*		.23	.04	6.39*	
RAN				.31**				.33***				.22*				.22*
Step 3	.31	.06	4.67*		.33	.02	1.56		.25	.02	1.67		.25	.02	1.34	
Phonemic awareness				.24*				.13				.16				.10
Phonemic STM				−.21*				−.12				−.12				−.13

Note. STM = short-term memory; RAN = rapid automatized naming.
* $p < .05$. ** $p < .01$. *** $p < .001$.

decoded a few times until they can be stored in orthographic memory. For the current sample, however, no serious delays in the acquisition of phonological decoding were evident by the end of Grade 1. However, although more or less any grapheme sequence can be decoded with reasonable accuracy, some children could not make use of this self-teaching mechanism as efficiently as the rest of the sample. For these children, Ehri's (2002) statement that "reading the word a few times secures its connections in memory" (p. 11) is not appropriate.

In the current study, we also examined the longitudinal development of spelling skills and found a strong relationship between early problems in phonological spelling units and later orthographic spelling skills. This finding is relevant in two respects. First, it shows that even in the phonologically transparent orthography of German, good competence in translating phonemic segments into a grapheme sequence is indispensable. The main difference from findings in the phonologically much less transparent orthography of English is probably that successful word identification via phonological decoding acts as a learning mechanism, so that understanding how the orthography maps onto spoken words is much easier to acquire and does not pose a serious hurdle to the majority of children. Second, on first glance it is not obvious why early phonological skills should have an influence on orthographic spelling. Orthographic markers in German are only partly phonology based. The different spellings of homophone pairs such as *fiel* (*he fell*) and *viel* (*many*) or *Wahl* (*election*) and *Wal* (*whale*) are obviously not phonologically motivated, as the word pronunciations are identical. Still, children with poor phonological skills seem to be at a serious disadvantage to store orthographic spellings in memory. It is, of course, possible that phonological problems are only an indicator for more general verbal deficits, so that children who show phonological deficits at the beginning of literacy instruction also have deficits in morphosyntactic skills that are relevant in spelling. Another explanation for the relation between early phonological skills and later spelling development is that the build-up of orthographic representations requires the formation of multiple associations between written and spoken words (Ehri, 1992; Perfetti, 1992). Children with phonological deficits might not be able to establish such multiple associations.

In addition to these findings on the long-term stability of reading fluency and spelling, the design of our longitudinal study also allowed us to examine the pattern of early prediction of phonological and naming speed measures for reading and spelling development over the full 8-year period of the study. So that readers interpret the findings adequately, it should once again be mentioned that the phonological awareness task applied in the present study was different from standard measures used in this field. Phonological awareness refers to the explicit access of the sublexical sound structure and is typically assessed by measures that require segmentation or manipulation of sound segments. However, earlier studies in our lab indicated that tasks requiring sound segmentation or manipulation are very difficult for German-speaking children before the onset of reading instruction (Mann & Wimmer, 2002), probably because sound games and reading preparation are largely absent from the preschool system in German-speaking countries. The imitation paradigm applied in the present study showed an adequate level of difficulty and therefore fulfilled the statistical requirements for the regression analyses presented here. An obvious concern is that rote memory of the critical word and its segments may boost performance. However, we note that the correlation between our phonological awareness measure and the phonological short-term memory measure was low. Furthermore, the short-term memory measure was not associated with any of the subsequent reading fluency measures or with the phonolog-

Table 5
Summary of Hierarchical Regression Analyses for Variables Predicting Orthographic Spelling in Grades 4 and 8

Variable	Grade 4 R^2	Grade 4 ΔR^2	Grade 4 ΔF	Grade 4 β	Grade 8 R^2	Grade 8 ΔR^2	Grade 8 ΔF	Grade 8 β
Model 1								
Step 1	.28	.28	21.46***		.36	.36	31.51***	
Nonverbal IQ				.20**				.34***
Letter knowledge				.20*				.23*
Step 2	.35	.08	6.67**		.42	.06	5.50**	
Phonemic awareness				.30**				.22*
Phonemic STM				.05				.10
Step 3	.37	.02	3.17		.43	.01	2.30	
RAN				.15				.12
Model 2								
Step 2	.30	.03	4.63*		.38	.02	3.32	
RAN				.15				.12
Step 3	.37	.07	5.86**		.43	.05	4.94**	
Phonemic awareness				.30**				.22*
Phonemic STM				.05				.10

Note. STM = short-term memory; RAN = rapid automatized naming.
* $p < .05$. ** $p < .01$. *** $p < .001$.

ical spelling measure in Grade 1. The measure was based on the idea that imitating the experimenter should be easier for children who understand that the experimenter is segmenting the simple words presented into functional sound units (i.e., phonemes).

In spite of the unconventional measure of phonological awareness, overall, earlier findings in German, Dutch, and Italian (de Jong & van der Leij, 1999, 2002; Di Filippo et al., 2005; Wimmer & Mayringer, 2002; Wimmer et al., 2000) can be confirmed. While the phonological measures (phonological awareness and phonological short-term memory) dropped out as significant predictors after first grade, naming speed assessed at school entry was a consistent predictor of reading fluency up to Grade 8. These findings seem to be different from findings with English-speaking children, for whom phonological awareness is often reported to be the best predictor of reading development (Cronin & Carver, 1998; Mann & Wimmer, 2002; Torgesen, Wagner, Rashotte, Burgess, & Hecht, 1997). It is possible that this finding was due to the fact that our imitation paradigm is not a phonological awareness task in the narrow sense—that is, children were not required to segment the phonemes of the presented words independently. Another explanation for this difference in findings might be that English studies usually do not assess the development of reading fluency but focus on the development of reading accuracy only. However, Kirby, Parrila, and Pfeiffer (2003) recently reported for a Canadian sample that phonological awareness assessed in kindergarten ceased to be a relevant predictor for word reading accuracy after Grade 2, while the prediction of kindergarten rapid automatized naming was only significant from Grade 3 on. It is thus possible that the same predictive patterns as reported here are also valid for English but that, as the acquisition of competent phonological decoding skills takes about 2 to 3 years longer in the phonologically opaque English orthography than in transparent orthographies such as German (Aro & Wimmer, 2003; Seymour et al., 2003), the change in predictive strength of phonological awareness and rapid automatized naming takes place later in English than in German.

A methodological limitation of the present findings is the high attrition rate. Only about 35% of the children of the first grade sample still participated in the final assessment. One third of the sample was lost because of missing addresses, but another third was located and chose not to participate. The most likely selection bias for the final assessment is that adolescents with poor literacy skills might have tended to avoid the embarrassment of an assessment of their reading and spelling skills and therefore declined. If this is the case, this effect would certainly restrict the representativeness of our findings. Given the fact that we found no major differences between Grade 8 participants and nonparticipants on the prediction measures, our findings may overestimate the predictive power of our prediction measures if, indeed, the lower end of literacy skills was underrepresented in the Grade 8 sample. In other words, if it was the poorer readers who decided not to participate in Grade 8, they did not have lower scores on the prediction measures than the possibly better readers who did participate. Still, we do not think that such a selective attrition has been going on in our sample, as on the Grade 8 standardized spelling test the average performance corresponded to the 54th percentile. If the lower end of the distribution of literacy skills were missing from our sample, the mean level of performance could be expected to be above average.

In conclusion, the findings of the current longitudinal study, which followed German-speaking children's development of reading fluency and orthographic spelling from the beginning of Grade 1 until Grade 8, confirm once more that for children who start into literacy development with certain risk factors that can be identified easily, the long-term prognosis is strikingly poor. Sometimes children are able to compensate for inefficient word reading skills if they have sufficient time (Walczyk, Marsiglia, Johns, & Bryan, 2004), and therefore reading comprehension is not deleteriously affected. However, the correlation between reading fluency and reading comprehension was still substantial (.64) for the Austrian sample of 15-year-olds participating in the Program for International Student Assessment (Landerl & Reiter, 2002), which indicates that a high percentage of dysfluent readers also experience serious comprehension deficits.

A final comment seems justified on the issue of intervention. We did not assess whether or what kind of intervention the poorer readers in our sample received over the years. If they did receive intervention, it did not induce serious improvements of their reading fluency. Most reading intervention programs today focus on phonological awareness and phonological decoding in reading. Given that phonological awareness is not strongly related to the development of reading fluency and that even the poorer readers of the present study were well able to phonologically decode words and nonwords already at the end of Grade 1, such intervention programs do not seem adequate for the problems these children experienced. Indeed, current evaluations show that such phonology-based programs have positive effects for children with low reading accuracy but that they do not have an influence on these children's low reading fluency (Torgesen, Rashotte, & Alexander, 2001). Serious research efforts are needed to develop and evaluate intervention programs that are specifically tailored to the problems of these dysfluent readers with high reading accuracy. Attempts in that direction (e.g., Levy, 2001; Thaler, Ebner, Wimmer, & Landerl, 2004) show that dysfluent reading is not only a highly stable characteristic but also one that is hard to remediate.

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