CLINICAL PRACTICE GUIDELINE

The Diagnosis and Treatment of Reading and/or Spelling Disorders in Children and Adolescents

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SUMMARY

Background: 3–11% of children and adolescents suffer from a reading and/or spelling disorder. Their poor written-language skills markedly impair their scholastic performance and are often associated with other mental disorders. A great deal of uncertainty still surrounds the question of the appropriate methods of diagnosis and treatment.

Methods: We systematically searched for pertinent publications in databases and literature reference lists, summarized the evidence in six tables, and examined some of it in a meta-analysis. Recommendations were developed in a consensus conference.

Results: A reading and/or spelling disorder should only be diagnosed if performance in these areas is below average. It should be determined whether an attention deficit-hyperactivity disorder, anxiety disorder, or disorder of arithmetical skills is also present. Reading and spelling performance should be reinforced with systematic instruction about letter-sound and sound-letter correspondences, letter-syllable-morpheme synthesis, and sound-syllable-morpheme analysis ($g' = 0.32$) (recommendation grade A). Spelling ability responds best to spelling-rule training (recommendation grade A). Irlen lenses, visual and/or auditory perceptual training, hemispheric stimulation, piracetam, and prism spectacles should not be used (recommendation grade A).

Conclusions: Evidence- and consensus-based guidelines for the diagnosis and treatment of reading and/or spelling disorders in children and adolescents are now available for the first time. Reading and spelling abilities should be systematically and comprehensively reinforced, and potential comorbid disorders should be sought and treated appropriately. The efficacy of many treatments now in use has not been documented; if they are to be used in the future, they must be tested in randomized, controlled trials. For adult sufferers, adequate diagnostic instruments and therapeutic methods are not yet available.

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Worldwide, some 3–11% of children and adolescents have a reading and/or spelling disorder (1–3). The ICD-10 distinguishes between combined reading and spelling disorder (prevalence: 8%) and isolated spelling disorder (prevalence: 7%). Isolated reading disorder (prevalence: 6%), which has so far not been included in the ICD-10, is similarly common (1). Reading disorder is characterized by many errors made during quiet reading and reading out loud of words, by noticeably slowed-down reading speed and impaired reading comprehension. This affects all school subjects, foreign languages or even the understanding of mathematical tasks (4). In spelling disorder, massive difficulties arise when children start learning to write. These include learning the relation between sound and letters and orthographically correct spellings of word components and complete words (5). In combined reading and spelling disorder, the symptoms of reading disorder and spelling disorder occur in combination.

Children with reading and spelling disorder are often seen in outpatient healthcare services—for example, in pediatric practices or public health services—for psychosomatic symptoms, such as headaches or stomach aches, nausea, and lack of motivation/drive. If children or adolescents repeatedly experience failures at school, they may develop severe fear of failure and negative self-conception of their own ability. The comorbidity with externalizing and internalizing disorders is correspondingly high (6). Some 20% of children and adolescents with a reading disorder develop an anxiety disorder, but depression and conduct disorders are also common (7–10). Untreated and without specific support, reading and spelling disorder often results in failure at, or absenteeism from school, with grave consequences for professional education and training and for psychological wellbeing in adulthood (11–13).

The diagnosis of reading and spelling disorder is inconsistent in medical and psychological/psychotherapeutic practice. This is partly based on different methodological approaches, diagnostic criteria, and testing methods. As far as treatment is concerned, a vast arsenal of different treatment methods is available that often have been evaluated not at all or only to an

Flow chart showing the literature search and selection for the overall area of treatment (14)

Search in electronic databases and reference lists using the search filters:

- "dyslexia" OR "developmental reading disorder" OR "dyslexia", "developmental" OR "reading disability", "developmental" OR "reading disorder" OR "reading disorder", "developmental" OR "word blindness" OR "spelling disorder" OR "developmental spelling disorder" OR "specific spelling disorder" OR Lesestörung OR Rechtschreibstörung OR Lese-Rechtschreibstörung OR Lese-Rechtschreibschwäche OR Leseschwäche OR Rechtschreibschwäche OR Legasthenie
- "at risk" OR "high-risk" OR "at-risk" OR "depress*" OR "behav*" OR "coordination disorder" OR "mental disorder"
- "remediation" OR "intervention" OR "treatment" OR "therapy", "therapeutics" OR "training" OR Förderung OR Therapie OR "train*" OR "intervent*" OR "treat"

RCT, randomized controlled trial; ERIC, Education Resources Information Center

unsatisfactory degree (15). For this reason, the effectiveness of support methods and the fitness for purpose, reliability, and validity of any diagnostic approach should be evaluated urgently, in order to be able to derive clear instructions and recommendations for clinical practice.

To this end, the German Association for Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy (*Deutsche Gesellschaft für Kinder- und Jugendpsychiatrie, Psychosomatik und Psychotherapie*, DGKJP) has presided over the development of an evidence based and consensus based (S3) clinical practice guideline for the diagnostic evaluation and treatment of children and adolescents with reading and spelling disorder.

Method

For the recommendations, comprehensive systematic literature searches of several databases were undertaken (PubMed, PsycInfo, ERIC, Cochrane, ClinicalTrials.gov, ProQuest) (Figure 1). Where possible the

data thus identified were evaluated by means of meta-analysis. The literature search included all publications up to and including April 2015. As far as we are aware, no new randomized controlled trials and systematic reviews were published between that time and the publication of the guidelines. We searched the databases PSYINDEX and Testzentrale. The identified literature was checked independently by two assessors for inclusion and exclusion criteria. *eBox 1* shows the inclusion criteria. All included studies were evaluated with regard to their methodological quality by using the checklists of the Scottish Intercollegiate Guidelines Network (SIGN) and assigned an evidence level by using the scheme of the Oxford Center for Evidence Based Medicine (OCEBM) (16).

In order to assess the methodological quality of the psychometric tests for capturing reading and spelling ability, we used an abbreviated version of the DIN 33430 Screen V2 checklist 1 (17). No evidence level was assigned. We assessed the manuals on the basis of central quality criteria (18), which had to have been

implemented in the diagnostic testing methods (*eBox 2*). In a consensus meeting that was moderated by a neutral party, the participating specialty societies voted (*eBox 3*) in a structured manner for each recommendation. Agreement of >95% was regarded as strong consensus, 75–95% as consensus, and 50–57% as majority agreement.

Diagnostic evaluation

For the diagnostic evaluation, three different diagnostic criteria are used in clinical practice that are based on the ICD-10 (19), which yield different prevalence rates of the disorder: the age/grade intelligence quotient (IQ) discrepancy criterion. The crucial question is which criterion or which combination of these criteria should be used in future to make a diagnosis. Since no empirical evidence was found regarding the different therapeutic effects, the course of the disorder, or heritability between children and adolescents, in whom a diagnosis of reading/spelling disorder was made on the basis of a discrepancy in terms of age/grade or IQ (www.kjp.med.uni-muenchen.de/forschung/leitl_lrs.php, evidence table for the purpose of diagnostic evaluation), none of the criteria is to be put to preferential use. One of the three criteria should therefore be used to base a diagnosis on. For the IQ discrepancy criterion, it needs to be ensured for making a diagnosis that below-average achievements apply in terms of reading and spelling ability. This means that the discrepancy from the age or grade should be at least one standard deviation (SD) (*Table 1*). Regarding psychometric testing methods, no criteria were available on the basis of which the instruments could have been compared. The guideline recommends which testing methods should be preferred in order to assess reading and/or spelling ability (*eTable 1*).

In addition to the appropriate diagnostic instruments, a detailed developmental, family, and school history should be taken, as well as a neurological and internal examination, an intelligence test, and a differential diagnostic examination with the aim of excluding

TABLE 1

Diagnostic criteria conform to guideline recommendations

Diagnostic criterion	Observed as	Expressed as
Age discrepancy criterion	Below average performance in the chosen testing method compared with age standard	At least percentile rank ≤ 16 or T value ≤ 40
Grade discrepancy criterion	Below average performance in the chosen testing method compared with standard grade performance; if available, use of school-type specific standard	At least percentile rank ≤ 16 or T value ≤ 40
Age or grade standard and intelligence discrepancy criterion	Below average performance in the chosen testing method compared with standard age or grade performance AND Unexpected poor performance in the chosen testing method compared with IQ	At least percentile rank ≤ 16 or T value ≤ 40 AND Discrepancy from respective T or IQ values ≥ 1 standard deviation

TABLE 2

Results of the meta-analysis

Intervention method	Effect sizes	References
Phonological awareness training	Reading performance: $g' = 0.28$; 95% CI $[-0.24; 0.80]$	(e33, e34)
Training in letter-syllable -morpheme synthesis and analyses of phonemes, syllables and morphemes	Reading performance: $g' = 0.32$; 95% CI $[0.18; 0.47]$ Spelling performance: $g' = 0.34$; 95% CI $[0.06; 0.61]$	(e34–e45)
Whole word reading training	Reading performance: $g' = 0.30$; 95% CI $[-0.11; 0.71]$	(e35, e39, e41, e45)
Reading comprehension training	Reading performance: $g' = 0.18$; 95% CI $[-0.18; 0.54]$	(e37, e46)
Auditory perception training	Reading performance: $g' = 0.39$; 95% CI $[-0.07; 0.84]$	(e47, e48)
Medication treatment	Reading performance: $g' = 0.13$; 95% CI $[-0.07; 0.32]$	(e49, e50)
Irlen lenses	Reading performance: $g' = 0.316$; 95% CI $[-0.01; 0.64]$	(e51, e53)

CI, Confidence interval

ocular vision disorders or auditory perception and processing disorders (20).

Differential diagnosis

If children or adolescents report blurred vision, sudden/rapid-onset tiredness, and headaches after reading for prolonged periods, as well as an increase in symptoms during the course of the school day, an eye-related reading disorder should be considered, which can have different causes:

- Refractive anomalies (refractive error), hyperopia (farsightedness)
- Latent and intermittent strabismus (heterophoria)
- Hypo-accommodation (reduced ability for accommodation to near distance)
- Convergence insufficiency.

The latter two disorders often occur in tandem (21). The recommended diagnostic approach is summarized in *eTable 2*. 6.7% of a population of primary school children with reading and spelling disorder were found to have ocular problems that may have caused the reading difficulties (22).

Peripheral hearing problems that may permanently impair language/speech acquisition and the acquisition of writing skills are additional important differential diagnoses. These can be subcategorized into conductive hearing loss, sensorineural hearing loss, and combined hypoacusis (23). The guideline recommends the following methods for diagnosing hearing problems in schoolchildren:

- Impedance audiometry with stapedius reflex measurement in order to assess the ventilation mechanism of the middle ear
- Otoacoustic emissions to test auditory cell function
- Determining hearing threshold levels by means of air and bone conduction.

An auditory disorder is to be regarded as relevant for speech where bilateral hearing loss (>25 dB in the ear with better hearing) has been present for more than three months or permanently in the main speech frequency range (between 500 and 4000 Hz). Even in low-grade hearing loss, schoolchildren display notable difficulties in distinguishing sounds, which is a basic condition for acquiring spelling/writing language skills.

Providing support

The guideline focuses on assessing the multitude of methodologically and substantially different therapeutic options regarding their effectiveness in treating reading and spelling disorder. In addition to symptom-specific approaches that directly target the reduced reading and spelling ability and their precursor skills and the so-called causal therapies, which support basic functions such as auditory and visual perception, medication treatments and a number of esoteric and alternative medical approaches exist.

A meta-analysis showed an improvement in reading and spelling performance only for symptom-specific approaches. Accordingly, these approaches are recom-

mended for treating such disorders. The included studies and results of the meta-analysis are shown in *Table 2*.

Reading performance can best be developed by using the systematic instructions of letter-sound correspondences and letter-syllable- and morpheme synthesis ($g' = 0.32$; 95% confidence interval [0.18; 0.47]) (24). Spelling performance is most effectively improved by using the systematic instructions of sound-letter correspondences, exercises analyzing sounds, syllables, and morphemes ($g' = 0.34$; [0.06; 0.61]) and by applying a training procedure to enable the acquisition and generalization of orthographic regularities (24–27). *Figure 2* shows relevant examples. Furthermore, the reading performance of children and adolescence with a reading disorder can be improved by presenting texts in large print (≥ 14 pt) and wider space between letters, words, and lines (≥ 2.5 pt) (28). Reading materials for affected students should therefore be selected accordingly.

The effectiveness of auditory or visual perception and processing training programs ($g' = 0.39$; [–0.07; 0.84]) (e1–e3), medication ($g' = 0.13$; [–0.07; 0.32]), and Irlen lenses ($g' = 0.316$; [–0.01; 0.64]) (e1–e3) was not confirmed by the meta-analysis (24). Controlled studies (e4–e6) have not shown any benefit for the effectiveness of neuropsychological hemisphere-specific stimulation training compared with no treatment. Alternative approaches (homeopathy, acupuncture, osteopathy, and kinesiology), food supplements, visual biofeedback, motor exercises and occlusion therapy (*eTable 3*) did not increase reading and spelling performance in affected children (e7–e11).

No evidence to date has shown that prism spectacles improve spelling/writing performance. Prism correction is used in heterophoria, but this does not explain the symptoms of reading and spelling disorder. The concept of visual angle defects should be distinguished from heterophoria, as this concept arises only once testing conditions have been used that are in accordance with the H J Haase measurement and correction methodology. Prisms are used when a fixation disparity has been noted. The aim is to allow the eyes as comfortable a visual angle as possible. This method for determining the fixation disparity is very controversial, and the entire methodology proposed by H J Haase is scientifically not accepted (e12, e13).

Support setting

The guideline includes recommendations on treatment initiation, treatment duration, therapists' qualifications, and the support setting (support given to individuals or small groups).

Affected children should receive support from their first school year, as an early start is more effective than a start from the second to sixth year (recommendation grade A) (29).

Support measures should be implemented in individual group settings or small groups settings ($\leq$ five

FIGURE 2

Evidence based reading interventions		Evidence based spelling interventions	
Approach	Phonics Instruction	Phonics Instruction	Orthographic trainings
Content	Interventions that systematically teach letter-sound-correspondences and decoding strategies that involve blending individual letters, syllables or onset and rimes to words.	Interventions that systematically teach sound-letter-correspondences and include segmenting a word into individual phonemes, syllables or onset and rimes.	Interventions that concentrate on the acquisition and application of morphological rules and orthographic regularities.
Example	<p>I. Circle the words that make the sound „a,, sound like in dad</p> <p>cat – mad – flag – ball</p> <p>II. Adding an „e,, at the end makes the vowel say its name and not its sound.</p> <p>made tube wine</p> <p>III. Read the words in syllables and than as a whole</p> <p>banana tomato</p>	<p>I. Complete the words</p> <p>r _ f m _ n</p> <p>II. Divide the word into its syllables</p> <p>com – pu – ter</p>	<p>I. The single vowel „-y,, (not -ay, -ey, -oy) changes to „i,, when adding a suffix unless the ending starts with „i,,.</p> <p>baby + es → babies</p> <p>II. Silent final -e words commonly lose the need for the -e when adding a vowel suffix.</p> <p>have + ing → having</p>

Examples of evidence based methods

persons) (recommendation grade A). No differences in effectiveness have been identified between interventions administered in individual sessions or group sessions (24). However, in order to make a decision about the support setting, existing comorbidities and the severity of the disorder should be considered.

The therapist's profession affects the effectiveness of the intervention. When measures were initiated by teachers and the study authors, the effectiveness of the support reached significance. When fellow pupils, parents, and university students administered the intervention, its effectiveness was not unequivocally confirmed (24, 30). For this reason, the interventions should be implemented by experts in reading and spelling development and its promotion (recommendation grade A).

Furthermore, a longer duration of the intervention is associated with a greater improvement in reading and/or spelling performance (24, 31). Children and adolescents with a reading and spelling disorder should therefore receive support for as long as it takes to reach an ability to read and spell that enables them to participate in public life in an age-appropriate way (clinical consensus point). In most cases this means several years of intense support and treatment, which is, however, often not provided because the healthcare system has no provision for funding it. For this reason, the prospects for young persons with reading and spelling disorder in terms of a scholastic development that matches their aptitude and talent and for psychosocial integration into society are lower than for their peers.

Comorbidities

The role of comorbidities for the effectiveness of therapeutic methods in the setting of reading and spelling disorder has thus far been underestimated. These comorbidities often include anxiety disorders, depressive symptoms, hyperkinetic disorder or attention deficit/hyperactivity disorder (ADHD) and absenteeism from school, and conduct disorders in adolescents. ADHD is four times more common in children and adolescents with reading and spelling disorder, and the prevalence in children whose reading and spelling disorder has already been diagnosed is 8–18% (7, 9, 32).

Furthermore, a notably increased prevalence of anxiety disorders (20%) and depressive disorders (14.5%) was found in young persons with reading and spelling disorder. The risk for being found to have an anxiety disorder in existing reading and spelling disorder is quadrupled. For social phobia, there are indications that the risk increases sixfold (7, 9, 10).

The comorbid occurrence of reading and spelling disorder and specific disorder of arithmetical skills is significantly increased. The prevalence rate was between 20% and 40% in children who had already been diagnosed with reading and spelling disorder. The risk of a disorder of arithmetical skills is increased by four to five times (33). The prevalence of both disorders in the total population is 3–8% (33–37).

Studies investigating the language performance of children and adolescents with reading and spelling disorder have shown a significant accumulation of expressive and/or receptive language disorder in children

FIGURE 3

Algorithms of guideline-conform diagnostic evaluation and treatment: The support program also applies for combined reading and spelling disorder.

and adolescents with reading and spelling disorder, but reliable prevalence rates cannot be derived (38, 39).

In sum, for a diagnosis of reading and spelling disorder, the comorbidities should be determined and included in the treatment plan.

Figure 3 shows the evidence based approach to diagnosis and support.

A need for action and research

A clear need for action and research exists in the areas of diagnosis and treatment of reading and spelling disorder.

Many testing procedures used in the diagnostic evaluation were not included in the guideline recommendations because they were of insufficiently low methodological quality. The reliable and valid ascertainment of precursor skills for the early detection of reading and spelling disorder is impossible by means of the tests currently available. Standardized spelling tests that can be used for the entire school year are lacking in Germany. Many tests can be used only at certain time intervals in the course of a school year because of their standardization. Reading tests for adolescents and adults do not exist in Germany; a diagnosis in these age groups is therefore almost impossible.

As far as treatment is concerned, a substantial need exists for research in the form of randomized controlled trials, for all interventional approaches and methods (40).

Hardly any prevalence studies are available from German-speaking countries that have collected data on comorbidities in reading and spelling disorder. High-quality studies have been published for this topic only in the context of specific disorder of arithmetical skills (1, 33). In the studies, regionality is of particular importance for the generalizability of the results to one's own situation, because of different diagnostic approaches and criteria, as well as environmental conditions. Furthermore, prevalence estimates of developmental disorders of scholastic skills should always be undertaken on the basis of unselected samples, as this is the only way in which to avoid biases.

Using the S3 guideline in clinical practice

The guideline should be used in all clinical, outpatient, and inpatient settings where children and adolescents with school-related problems and associated psychosomatic symptoms or psychological disorders are seen. However, the guideline also provides recommendations for the diagnostic evaluation and treatment in the children's eye care center, in ear, nose, and throat practices, and in the pediatric audiological examination for the diagnostic evaluation of children with hearing, reading, and spelling problems. The provision of targeted support interventions in reading and spelling disorder is currently not covered by the statutory health insurers, which means that those affected have to fund their own treatment. The support methods on offer are multifarious and confusing; their effectiveness is

KEY MESSAGES

- The diagnosis of reading and spelling disorder should be based on the discrepancy between the reading and/or spelling level and the age norms, grade norms, or intelligence (IQ). Reading and spelling disorder should be diagnosed only if the reading and/or spelling performance differs by at least one standard deviation from the age or grade norms.
- For the purposes of the diagnostic evaluation, it should be ascertained whether attention deficit syndrome (ADS), attention deficit/hyperactivity disorder (ADHD), anxiety disorder, or disorder of arithmetical skills is present.
- Interventions should target the symptoms of reading and spelling disorder and consider comorbid disorders.
- Children with difficulties in acquiring reading and spelling skills should receive supportive measures as early as in their first year.
- The support intervention should continue until the achieved reading and spelling ability enables a patient to participate in social and public life in an age-appropriate way.

unclear. Methods whose effectiveness is unclear or lacking should not be used. The guidelines provide clear therapeutic recommendations whose implementation helps save costs and avoid serious psychosocial stress resulting from insufficient/unsatisfactory therapy.

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Conflict of interest statement

The authors declare that no conflict of interest exists.

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Supplementary material

For eReferences please refer to:
www.aerzteblatt-international.de/ref1616

eBox, eTables:

www.aerzteblatt-international.de/16m0279

Erratum

In the article “Breast reconstruction following cancer treatment” by Gerber and colleagues (issue 35–36/2015), an acronym in a picture legend on page 595 was spelled out wrongly: it says, incorrectly, “MRM: modified radical hysterectomy.” It should have said; “MRM: modified radical mastectomy.”

MWR

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eBOX 1

Overview of inclusion criteria according to the research question

Study inclusion criteria

Diagnostic evaluation of discrepancy to age/grade norms or IQ

1. Study comparing children and adolescents, whose diagnosis of reading and spelling disorder is based on the intelligence quotient (IQ) discrepancy criterion, and adolescents, in whom reading and spelling disorder was diagnosed on the basis of a discrepancy of age norms of their reading and/or spelling performance.
2. The study design is a systematic review, an analytical study, or a cross sectional study.

Testing method

1. German-language approach to capturing the relevant skill set (reading, spelling, phonological processing of information and naming speed, language skills, mathematical skills, arithmetical performance, auditory perception and processing, language/speech skills, attention).
2. Includes standard values that have been tested for appropriateness in the past 10 years.

Support

1. Controlled intervention study, that collected data on reading and/or writing skills before and after the intervention.
2. Study population consists of children and adolescents, whose reading and/or spelling performance was at least on or below the 25th percentile or who had been diagnosed with reading and/or spelling disorder.

Comorbidities

1. Prevalence study with epidemiological or selected samples that enabled prevalence estimates of comorbid attention deficit/hyperactivity disorder (ADHD), anxiety, depression, auditory processing and perception disorder, disorder of arithmetical skills and speech/language disorder in children and adolescents with reading and/or spelling disorder.
2. Selected samples had to consist of children and adolescents with reading and/or spelling disorder.

eBOX 2

Central quality criteria for assessing tests

- The theoretical basis has been described in detail.
- The standard values are consistent with the relevant reference group or target group.
- The procedural instructions are formulated in such a way that different persons will be able to perform the procedures, evaluate them, and interpret them in comparable ways.
- The reliability was determined by using a retesting method.
- The way in which the validity was determined takes into account the diagnostic question and target group for the procedure.
- The standard sample per age range/standard time period was a minimum of 250 persons.

eBOX 3

Participating organizations

- **Publishers: AWMF=Association of the Scientific Medical Societies in Germany (AWMF):**
 - German Association for Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy (DGKJP)
- **Other participating organizations:**
 - Professional Association of Children's and Young People's Physicians (bvkj)
 - Professional Association of Child and Adolescent Psychotherapists (bkj)
 - German Society of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy (BKJPP)
 - Professional and specialist association for vocational remedial teaching (BHP)
 - Federal Working Group of Clinical Directors for Child and Adolescent Psychiatry, Psychosomatics, and Psychotherapy (BAG)
 - Federal Chamber of Psychotherapists (BPTK)
 - Federal Association for Dyslexia and Dyscalculia (BVL)
 - Federal Association for behavioral therapy in children and adolescents (BVKJ)
 - German Society of Pediatrics and Adolescent Medicine (DGKJ)
 - German Society of Phoniatrics and Pediatric Audiology (DGPP)
 - German Psychological Society (DGPs)
 - German Society for Social Paediatrics and Adolescent Medicine (DGSPJ)
 - German Ophthalmological Society (DOG)
 - German Federal Association of Academic Language/Speech Therapists (dbs)
 - German Federal Association for Logopedics (dbl)
 - Germany's Association of Occupational Therapists (DVE)
 - The German Society of Speech-, Language-, and Voice Pathology (DGSS)
 - Association for Integrative Learning Therapy (FiL)
 - German Society of Neuropsychology (GNP)
 - Association for special needs education (vds)
 - Association for analytical child and adolescent psychotherapists in Germany (VAKJP)

eTABLE 1

Recommended methods for testing reading and spelling performance

Testing method	Period of use	Variables measured	Authors
A reading comprehension test for pupils in years 1 to 6 (ELFE 1–6)	Years 1–6, the final 2 months before end of year and in years 2–6, mid-year (2 months before to 1 month after intermediate school report)	Reading comprehension test: 3 subtests are used for word comprehension (the correct term has to be selected from 4 alternatives for an item in a picture), sentence comprehension (the appropriate word has to be marked out of 5 alternatives), and text comprehension (short pieces of text are given, and a question is asked relating to each one).	(e14)
Reading speed and comprehension test (LGVT-R 5–13)	Year 6–9, additionally year 10 in intermediate school and years 10 and 11 in grammar school	Determining reading comprehension and reading speed: pupils are instructed to read a piece of text and select at intervals in the text the appropriate word from three alternatives (by underlining it).	(e15)
Battery of reading tests for pupils in years 6–7 (LESEN 6–7)	Year-end years 6 and 7	Determining basic reading competence and text comprehension: in order to test basic reading competence, participants have to read from a list of simple sentences as many as they can within 3 minutes and assess these for consistency of content. Text comprehension is analyzed by using an expository and a narrative text with 17 multiple choice comprehension questions for each one.	(e16)
Battery of reading tests for pupils in years 8–9 (LESEN 8–9)	Year-end years 8 and 9	Determining basic reading competence and text comprehension on the basis of 2 subtests: in order to test basic reading competence, participants have to read from a list of simple sentences as many as they can within 3 minutes and assess these for consistency of content. Text comprehension is analyzed by using an expository and a narrative text with 19 multiple choice comprehension questions for each one.	(e17)
Würzburg quiet reading test – revision (WLLP-R)	End of year 1 to end of year 4	The WLLP-R measures the decoding speed by using words juxtaposed with 4 alternative images each. The corresponding image has to be marked.	(e18)
German spelling test for years 1 and 2 (DERET 1–2+)	End of years 1 and 2 and start of years 2 and 3, respectively	The test measures spelling skills and provides an analysis of the spelling mistakes. It consists of a combination of pieces of continuous text for dictation and a piece of fill-in-the blanks text.	(e19)
German spelling test for years 3 and 4 (DERET 3–4+)	End of years 3 and 4 and start of years 4 and 5, respectively	In addition to spelling skills, skills in the area of punctuation and spoken language can be assessed and spelling mistakes can be analyzed. The test consists of a combination of pieces of continuous text for dictation and enable an ecologically valid assessment of the spelling performance of primary school pupils, and a piece of fill-in-the blanks text.	(e20)
Hamburg writing sample 1–10 (HSP 1+, HSP 2, HSP 3 HSP 4–5, HSP 5–9)	HSP 1+: middle of year 1 (January/February), penultimate and final school months in year 1, middle of year 2 (January/February) HSP 2: in the final 3 months of 2 nd school year. HSP 3: 15 th –23 rd week in the 3 rd school year and 33 rd –44 th week in 3 rd year HSP 4–5: 15 th –23 rd school week, 33 rd –44 th week in 4 th year 4 and 1st–12 th week of year 5 HSP 5–10: the final 3 month in each year	Individual words need to be written into the blank gaps in a piece of text. The evaluation is done according to the total number of mistakes and spelling strategies (alphabetical, orthographic, morphemic, and wider-context strategy).	(e21)
Salzburg reading the spelling test (SLRT II) – reading test	One minute reading fluency tests: end of 1 st year, 2nd–4 th year (separate standards for 1 st and 2 nd half-year), 5 th and 6 th year (second-level primary and intermediate school), young adults (students with A-levels, apprentices, university students).	The test consists of the one-minute reading fluency test. The reading test requires reading out loud words or pseudo-words within a time period that is restricted to one minute. Reading performance can be assessed from school year 1 into adulthood.	(e22)
Salzburg reading the spelling test (SLRT II) – spelling test	The spelling test can be used during the period of the 2 nd year up to the start of year 5.	Dictated spelling of words should be inserted into sentence frameworks in an orthographically correct fashion.	(e22)
Weingarten basic vocabulary spelling test for years 1 and 2 (WRT 1+)	In the final 2 months of year 1 at primary school; in the initial 3 months of the 2 nd year, and in the middle of year 2	Spelling individual words in the fill-in-the-blanks text: this is available in parallel forms containing 25 items each. Qualitative evaluation of spelling mistakes is optional.	(e23)

Testing method	Period of use	Variables measured	Authors
Weingarten basic vocabulary spelling test for years 2 and 3 (WRT 2+)	In the final 3 months of year 2 or in the initial 3 months of year 3 and in the middle of year 3.	Spelling individual words in the the fill-in-the-blanks text: this is available in parallel forms containing 43 items each. Qualitative evaluation of spelling mistakes is optional.	(e24)
Weingarten basic vocabulary spelling test for years 3 and 4 (WRT 3+)	In the final 3 months of year 3 or in the initial 3 months of year 4 and in the middle of year 4.	Spelling individual words in the the fill-in-the-blanks text: this is available in parallel long forms containing 55 items each and in parallel short forms containing 16 items each. Qualitative evaluation of spelling mistakes is optional.	(e25)
Weingarten basic vocabulary spelling test for years 4 and 5 in primary school and second level primary school (WRT 4+)	In the final 3 months of year 3 or in the initial 3 months, in the middle and in the final 3 months of year 5 in general secondary schools or similar school types.	Spelling individual words in the the fill-in-the-blanks text: this is available in parallel long forms containing 60 items each and in parallel short forms containing 20 items each. Qualitative evaluation of spelling mistakes is optional.	(e26)

eTABLE 2

Diagnostic evaluation by ophthalmologist and orthoptic optician in differential diagnosis of reading and/or spelling disorder versus eye-related reading disorder (modified from [e53])

History	Family-, patients' own, ophthalmological and school history
Visual acuity	Far distance/near distance, right/left eye/binocular, with/without correction
Eye position	Single cover test far distance/near distance, light/object
Eye mobility	With light or object
Convergence reaction	With object
Accommodation	Near-point convergence measurement: right/left eye, using small object
Fusional vergence amplitude	Free space, prisms
Stereopsis	TNO stereoscopic vision test/Lang test
Ocular findings	Anterior segments, retina, optic nerve
Refraction	Objective identification of a refractive error after accommodation has been blocked by medication (cycloplegia)
Spectacles	Establishing whether spectacles are being worn

eTABLE 3

Overview of non-symptom-oriented intervention methods without or with lacking evidence

Method	Examples
Hemisphere-specific stimulation	Tachistoscopic presentation of different stimuli (words) in the left or right visual hemifield, in order to compensate in the respective cerebral hemisphere the correction of the word processing ability that is not correctly developed.
Irlen lenses	Colored spectacle lenses are worn for all reading activities, with the aim of filtering out disruptive wavelengths from the light spectrum, thus enabling easier reading.
Visual perception and processing training	Exercises to improve visual differentiation ability and gaze control, fixation and discrimination tasks. Visual perception is supported as the basis of successful written-language acquisition.
Auditory perception and processing training	Exercises to learn to distinguish pitch, volume, and rhythm and for directional hearing and differentiating sound sequences, with the aim of improving auditory perception as the basis of successful written-language acquisition.
Alternative medical methods	These include, for example, homeopathy, osteopathy, and kinesiology, as well as Bach flower therapy. The aim is to improve affected children's ability to learn by eliminating psychological/biochemical imbalances or learning obstacles.
Food supplements	Ingestion of polyunsaturated fatty acids (ethyl-eicosapentaenoic acid [EPA]) in order to improve reading ability.
Occlusion treatment	One eye is covered up during reading activities, in order to improve binocular stability.
Motor exercises	Exercises to support body perception and coordination and to eliminate persistent neonatal reflexes.