Max Planck Research Group

Reading Education and Development (REaD)

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Research Team 2014–2016

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Introductory Overview

The Max Planck Research Group "Reading Education and Development" (REaD) investigates the underlying structure of reading skills and their development across the lifespan. To this end, the Research Group assesses the component processes of reading longitudinally and analyzes their interactions. This approach will allow the researchers to provide a more detailed description of the various subprocesses of reading and to analyze their conditions and consequences. These insights, in turn, will enable the Research Group to identify the processes that should be targeted by effective remedial programs in reading education.

Reading is one of the most important, but also one of the most complex, inventions in human history. In our information-oriented society, it is vital to be able to read texts accurately and efficiently. People who lack these skills are at a serious risk of marginalization: Adults with functional illiteracy often find themselves socially isolated; adolescents who are unable to write a letter of application fail to find a job.

In contrast to learning to talk, children do not learn to read spontaneously, but need instructional help and support. Yet many children have problems with reading acquisition and remain unable to understand even simple texts by the end of their compulsory education. How can we help these children?

Reading is a cognitive skill that involves a number of interacting processes located at different levels within a general hierarchy. It is unclear which are important for children's reading development and how they interact. Furthermore, it is likely that children with reading difficulties have different types of deficits and need different kinds of support.

The Max Planck Research Group REaD was launched in summer 2012 with the aim of investigating the underlying structure of reading skills and their development over childhood and adolescence. To this end, we assess the processes that underpin reading and analyze their interactions at different stages of reading development. This approach will provide a more detailed description of the various components of the reading system and their role in reading development. These insights, in turn, will enable us to identify the processes to be targeted by effective intervention programs in reading education.

A distinctive characteristic of the REaD group is that it takes an integrative approach to the investigation of reading: Theoretically, we combine elements from linguistics, psychology, and education. Empirically, we investigate the reading process as a whole—from reading single words to processes on the text level. Methodologically, we combine cross-sectional and longitudinal designs as well as corpus studies and experimental paradigms from cognitive psychology.

Figure 1. The acquisition of linguistic abilities before school is important for later reading development.

Figure 2. Most processes involved in reading are influenced by the amount of children's reading behavior.

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The research agenda of the REaD group is structured around four main projects:

(1) In the *childLex* project, we have established a linguistic corpus of German-language writing for children. It is complemented by the *InLex* project, which investigates interindividual differences in the mental lexicon of children in different age groups. Establishing such norms is essential for the design of experimental studies and training programs.

(2) In the *DeveL* project, we are collecting behavioral data for a selected set of words from participants across the complete lifespan. These data are critical for the development of the next generation of computational models of visual word recognition.

(3) The *DevTrack Study* investigates reading processes using eye-tracking techniques. This approach allows us to analyze children's reading of connected text during natural reading.

(4) Two interconnected longitudinal studies investigate interindividual differences in reading development. The *OPeRA* project focuses on children's use of different orthographic grain sizes during reading development in school. The complementary *PLAiT* project concentrates on the transition from kindergarten to grade 1.

Furthermore, we were able to obtain external funding for three additional projects that extend the research agenda of the group. This includes the *MusiCo*, which investigates the effects of musical training in kindergarten on children's later reading; *ERIC*, which focuses on the effects of teachers' classroom activities on children's reading processes; and *Morpheme*, which explores children's morphological development in German and French.

Figure 3. *childLex* comprises 500 children's books.

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childLex: A Corpus of German-Language Writing for Children

childLex is a linguistic corpus that has been collected from a large number of children's books in order to investigate German-language writing for children. The complementary *InLex* project focuses on interindividual differences in the structure of children's mental lexicon.

Linguistic databases for children are important tools for developmental studies of reading and to select stimulus materials for experimental studies and for investigating children's written and spoken language skills. For adults, a wide selection of corpora is now available, but these databases may not be adequate for children.

In order to account for potential differences between adults and children, specialized corpora for children have been collected in some languages (e.g., English, French, Spanish, Italian). For German, however, there was previously no electronic database of materials intended to be read by children. To fill this gap, we have compiled the *childLex* corpus to investigate German-language writing for children and to establish an online database that gives users access to a wide selection of linguistic variables.

childLex provides separate norms for children aged in grades 1 to 2, grades 3 to 4, and grades 5 to 6. It is based on 500 books that vary widely in terms of length and content.

In order to maximize the number of words in each age group, we oversampled books for beginning readers. Books were scanned manually, converted into text, and annotated using several algorithms: First, the text was divided into distinct words (tokenization). Next, the base form of each word was determined (lemmatization). Finally, words were assigned a syntactic category (noun, etc.). *childLex* comprises approximately 10 million words (tokens). These are distributed over 170,000 types (distinct word forms and 110,000 lemmas (base forms). We distinguish between variables at the lexical (e.g., frequency, length, neighborhood size) and sublexical level (e.g., letter and syllable characteristics).

Detailed descriptions of the *childLex* database have been published in both international (Schroeder, Würzner, Heister, Geyken, & Kliegl, 2015a) and national (Schroeder, Würzner, Heister, Geyken, & Kliegl, 2015b) journals. An online version of the database is available to the scientific community on www.childlex.de.

In addition, we have investigated differences

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Are "Child" and "Adult" Words Processed Differently by Children and Adults?

Do the differences in children's and adults' linguistic input affect their behavior in visual word recognition tasks? To investigate this issue, we chose 20 "child" words (that are frequent in *childLex,* but infrequent in a corpus for adults; e.g., "pirate," "fairy") and 20 "adult" words (that are frequent in an adult corpus, but not in *childLex;* e.g., "tax," "culture"). Four age groups (children, adolescents, younger adults, older adults) performed a lexical decision task using these words. Their response accuracies are shown in Figure 4: Children showed a processing advantage for child words; adolescents performed similarly on both types of words; and adults showed a processing advantage for adult words.

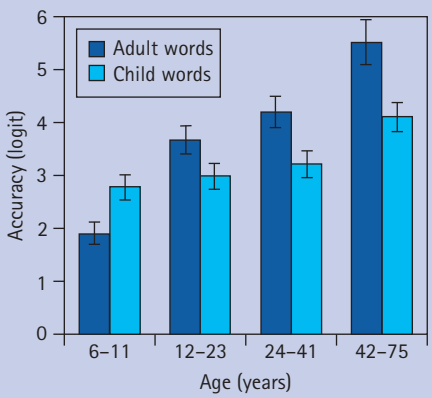

Figure 4. Response accuracy for "child" and "adult" words in different age groups.

Box 1.

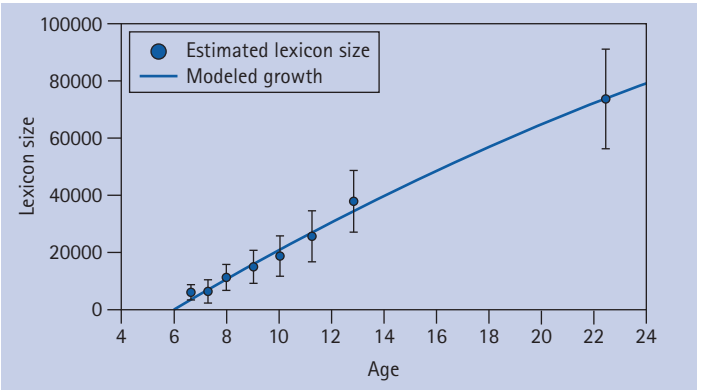

Figure 5. Development of lexicon size by age (adapted from Segbers & Schroeder, 2016).

in the print environment of different age groups (Würzner, Heister, & Schroeder, 2014) and the distribution of phonological and morphological categories within the corpus (Würzner & Schroeder, 2015). Further analyses will focus on linguistic questions, such as determining the variables that influence lexical development during childhood, as well as more applied issues, such as how to assign text difficulty levels to books.

InLex: The Individual Lexicon in Reading Aquisition

How many words does a child read? How many words are stored in his or her mental lexicon? What do these lexical representations contain and how are they connected? The *InLex* project addressed these issues and their impact on children's word recognition.

The mental lexicon can be regarded as a "word storage" which comprises information about all known words. It includes lexical characteristics, such as the number of known words (lexicon size), how often they have been encountered (frequency), and the number of similar words that exist in the language (neighbors). Since language development is modulated by several internal and external factors, individuals differ in the size and content of their mental lexicon. Interindividual differences in the composition of the mental lexicon could be responsible for differences in the visual word recognition process. The aims of the *InLex* project were (1) to develop a method to estimate individual lexical characteristics and (2) to describe their development as well as their effect on visual word recognition. The underlying rationale of the project was to use a sampling approach using the *childLex* corpus. Using this method, we were able to determine how many words children with varying reading input sizes know (see Figure 5; Segbers & Schroeder, 2016). Using this method, we were also able to estimate how often a specific word has been encountered by children who differ in their reading input size. Such differences in "individual frequencies" are able to account for a large proportion of developmental differences in children's reading development. Figure 6 shows the effect of the new individual frequency measure, which indicates that the different age groups constitute different parts of one underlying developmental curve.

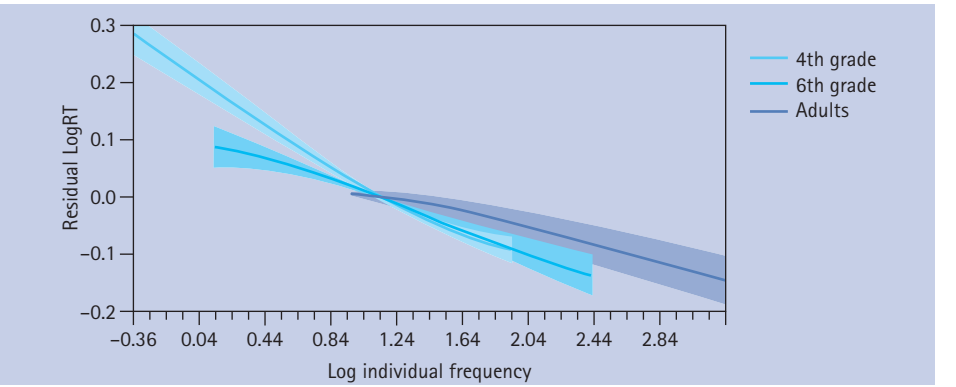

Figure 6. The effect of individual frequency in the three age groups combined.

DeveL: The Developmental Lexicon Project

The *Developmental Lexicon Project (DeveL)* investigates how visual word recognition processes change during reading development and across the lifespan. These data will be used to extend existing computational models of visual word recognition.

The process of word recognition, in which print is converted into linguistic information, is fundamental for reading. The impact of most word characteristics (length, frequency, etc.) on this decoding process is likely to change over time. However, none of the current models of visual word recognition explicitly includes a developmental dimension. One reason is that few studies have systematically compared the impact of linguistic variables on word processing across different age groups. For example, the *English Lexicon Project*, which was a multiuniversity effort to provide a database for the processing of 50,000 English words, investigated only adult readers. The aim of the *DeveL* project is to provide the first database on word recognition in German.

To this end, we selected 1,152 German words covering a broad range of linguistic characteristics that are considered crucial in developmental theories of written language acquisition. In a cross-sectional study, these words were presented to participants of different age groups, including children at different stages of reading development, younger adults, and older adults. Overall, data from 430 children in grades 1-6 were collected in computerized single sessions. In addition, younger (20–30 years old) and older adults' (65–75 years old) performance for the same words was assessed. Word recognition performance was measured using lexical decision and naming paradigms, which are commonly used in psycholinguistic research to assess lexical processing. To further inves-

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Schröter, P., & **Schroeder, S.** (2017). The developmental lexicon project: A behavioural database to investigate visual word recognition across the lifespan. *Behavior Research Methods.* Advance online publication. doi:10.3758/s13428-016-0851-9

Hasenäcker, J., Schröter, P., & **Schroeder, S.** (2017). Investigating developmental trajectories of morphemes as reading units in German. *Journal of Experimental Psychology: Learning, Memory, and Cognition.* Advance online publication. doi: 10.1037/xlm0000353

The Dual-Route Model of Visual Word Recognition

A widely accepted computational model of visual word recognition is the Dual-Route Model. It postulates two ways by which print can be converted into meaning (see Figure 7). First, words can be decoded via a sublexical route using grapheme–phoneme rules that are applied serially from left to right, letter by letter. Second, words can be processed via a lexical route. Here, the meaning and pronunciation of a word as a whole are retrieved from its representation in the mental lexicon. This process is assumed to happen quickly and in parallel.

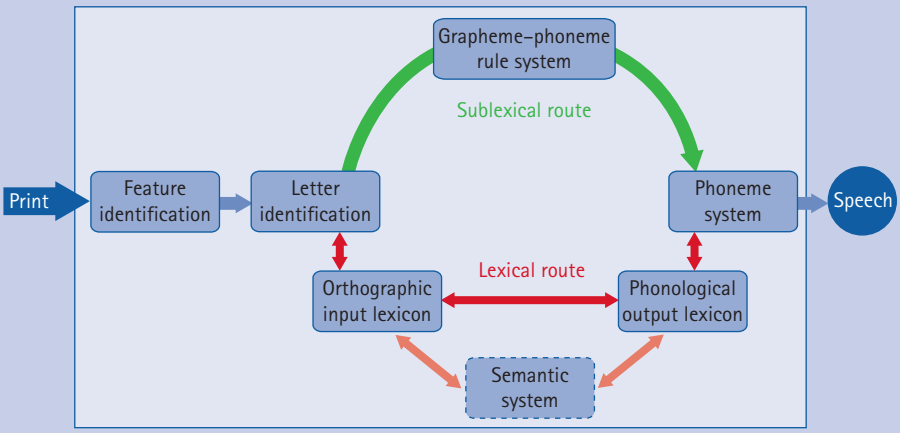

Figure 7. The Dual-Route Model of visual word recognition.

Box 2.

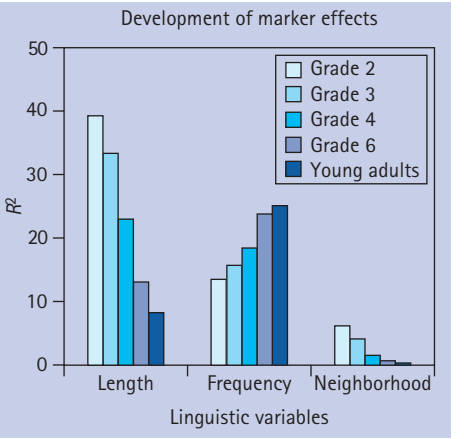

Figure 8. Percentage of variance accounted for by word length, word frequency, and orthographic similarity in the *DeveL* project.

tigate the impact of different reader variables on processing, we implemented measures of reading speed, vocabulary knowledge, and nonverbal intelligence. The three main aims of this project are to identify: (1) which linguistic features affect word recognition processes in German, (2) how their influence changes over time, and (3) whether the observed developmental patterns show interindividual differences.

The data of the *DeveL* project have been made available to the scientific community (Schröter & Schroeder, 2017) with the aim of helping researchers to advance theories and computational models of visual word recognition that include a developmental perspective. In addition, these data can be used to investigate the development of linguistic marker effects on the lexical level.

For example, we analyzed the correlations between three important linguistic marker effects—word length, word frequency, and neighborhood size—and participants' response behavior in different age groups (Schröter & Schroeder, 2017). Figure 8 shows the amount of explained variance ($R^2 \times 100$) that was explained by these three variables in children's (grades 2–6) and young adults' response latencies.

Results show that children's responses at the beginning of reading instruction were heavily affected by word length, which predicted about 40% of the variance. This percentage decreased steadily during development to a value of about 8% in younger adults. Orthographic neighborhood size showed a similar developmental trend, but to a smaller extent. By contrast, correlations with word frequency showed an increasing developmental pattern from about 13% in grade 2 to 25% in young adults. This demonstrates that orthographic and lexical information is used differently by children and by adults.

In another analysis of the *DeveL* data, we investigated processing differences between multimorphemic words (compounds *cook+book,* prefixes *un+learn,* and suffixes *read+able*) and monomorphemic words (*pencil;* Hasenäcker, Schröter, & Schroeder, 2017). This is of great interest because the vast majority of German words are multimorphemic. Results indicate that morphological structure is helpful for fast and efficient word recognition even for beginning readers and there is a specific developmental pattern (see Figure 9): Compounds are read faster than monomorphemic words in grade 2, while suffixed and prefixed words are read faster than monomorphemic words in grades 3 and 4, respectively. This contradicts the common assumption that words with different morphological properties have the same developmental trajectory and it shows that reading instruction should take specific morphological structures into account to optimally support children at different reading levels.

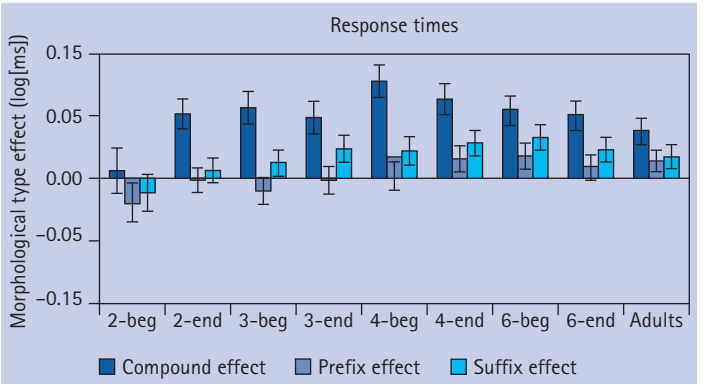

Figure 9. Compound, prefix, and suffix effects (differences between multimorphemic and monomorphemic words) for readers in different age groups (adapted from Hasenäcker, Schröter, & Schroeder, 2017).

DevTrack: The Developmental Eye-Tracking Study

Reading is more than decoding single words. With the *Developmental Eye-Tracking Study (DevTrack)* we aim to add depth to our understanding of children's natural reading processes by tracking their eye movements as they read sentences and texts.

Eye movements have long been used to track cognitive processes during complex tasks, such as visual search, scene perception, and reading. The eye-tracking research of the early 20th century established much of what we know today about typical eye movements; for instance, that the eyes move in a series of jumps (saccades) and pauses (fixations) and that information is processed only during fixation periods. During reading, adult eye movements generally consist of saccades of 7 to 9 characters and fixations of 200 to 250 milliseconds. The characteristics of eye movements are also subject to developmental changes, however, and the efficiency of eye movements during reading is thought to be strongly related to reading skill (Schroeder, Hyönä, & Liversedge, 2015). Skilled adult readers generally make long saccades, fixate words longer, and skip predictable words. We know that the eye movements of skilled adult readers and beginning readers differ substantially. We also know that individuals differ in their reading skill. Longitudinal designs, as employed in *DevTrack,* are therefore vital to capture both individual differences in the reading skill of beginning readers and the development of reading skill over time. *DevTrack* will be one of very few longitudinal studies that have attempted to tease apart the individual and developmental aspects of reading acquisition at the German elementary school level. Two mechanisms are known to drive the efficiency and development of eye movements. Foveal reading processes are involved when a word is focused directly; parafoveal processes are relevant when information about letters and words to the right of the fovea is extracted. In *DevTrack,* we investigated the development of these processes.

Foveal Processes in Reading

In a study focusing on the foveal processes of beginning readers in grade 2, we investigated the effects of word length and frequency on children's fixation durations, landing positions, and refixation rates (Tiffin-Richards & Schroeder, 2015a). Children read sentences with embedded target words in an experimental design in which word length and frequency were manipulated independently of one another. We found significant effects of word length and frequency for both children and adults while effects were generally greater for children. Our results illustrated in Figure 10 also show that children in grade 2 typically fixated both long and short words multiple times, whereas adults tended to fixate each word only once. Adults' refixation probability was only high when they first landed on the first or second letter in a long word, while children refixated long words regardless of where their first fixation landed. This suggests that children's default reading strategy involves fixating long words multiple times, presumably because single fixations are insufficient for full lexical processing.

Parafoveal Processes in Reading

In another study (Tiffin-Richards & Schroeder, 2015b), we investigated how children's processing of information in the parafovea

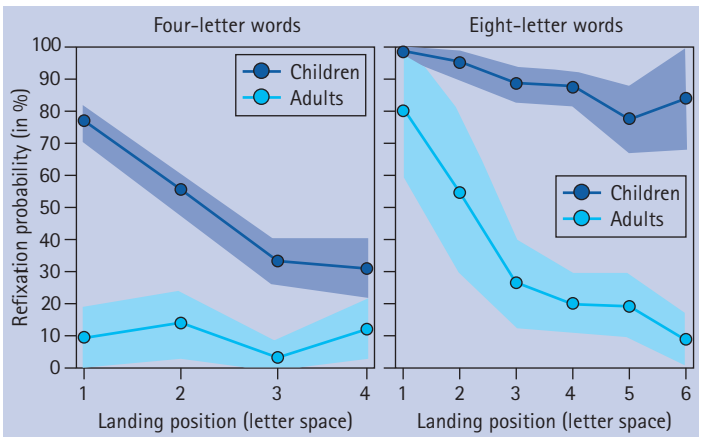

Figure 10. Children's and adults' refixation probability for short and long words as a function of their initial landing position (adapted from Tiffin-Richards & Schroeder, 2015a).

Key References

Schroeder, S., Hyönä, J., & Liversedge, S. P. (2015). Developmental eye-tracking research in reading: Introduction to the special issue. *Journal of Cognitive Psychology, 27,* 500–510. doi:10.1080/20445911.2015.1046877

Tiffin-Richards, S. P., & **Schroeder, S.** (2015a). Word length and frequency effects on children's eye movements during silent reading. *Vision Research, 113,* 33–43. doi:10.1016/j.visres.2015.05.008

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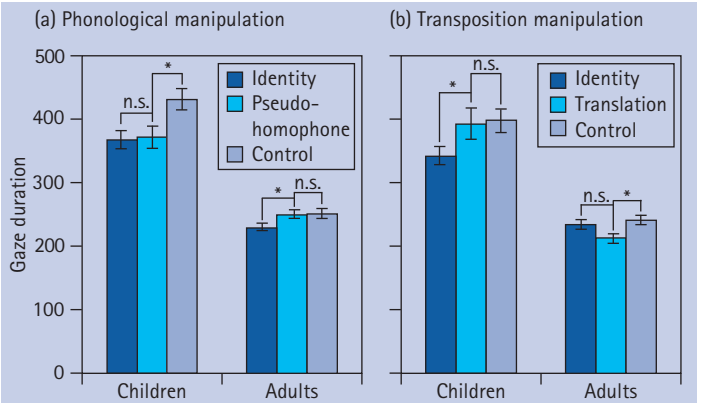


Figure 11. Findings on the parafoveal preview benefit.

changes during reading development. Studies have found that adults extract specific word information (e.g., orthographical and phonological) from the parafovea. This information can then be integrated when the word is fixated foveally, facilitating the word recognition process. The quantity and type of information that can be processed parafoveally by beginning readers remains unclear, however. This question can be addressed using the boundary paradigm illustrated in Box 3. We concentrated on two marker effects that show differences in developmental reading: phonological and orthographic preview benefits. In order to test phonological preview benefits, either a nonword that is pronounced similarly to the target word (e.g., "cl**ew**" for the target word "cl**ue**") or an orthographically matched control word (e.g., "cl**on**") is shown in the parafovea. If the target word is processed faster in the pseudohomophone condition than in the control condition, this indicates that phonological information has been accessed. By a similar logic, transposition preview effects can be used to quantify the amount of orthographic processing in the parafovea. As orthographic processing becomes more parallel during reading development, the encoding of the exact position of a letter becomes less important, and words with transposed letters (e.g., "b**na**d") are frequently mistaken for the real word (e.g., "b**an**d"). Results indicate that children, but not adults, showed phonological preview benefit effects (see Figure 11). This suggests that children rely more on phonological decoding processes during parafoveal processing than adults. By contrast, adults, but not children, showed transposition preview benefit effects. This indicates that children do rely more on the exact position of letters within a word than adults. Taken together, both findings are consistent with a developmental trend from sublexical to lexical processing.

In the main study of the *DevTrack* project, we investigated how foveal and parafoveal processes develop by following 100 children from grade 2 to grade 4. Data collection was completed in summer 2016. We are now preparing our first publications that will describe developmental changes in eye-movement behavior over the first years of elementary school and their relationship to other skills, such as lexical and oculomotor efficiency.

Investigating Parafoveal Processing: The Boundary Paradigm

In the boundary paradigm, target words are presented as manipulated previews until the reader's eyes move to bring them into focus. When the first saccade on the target word is made, the preview ("clew") is exchanged with the target word ("clew"; see Figure 12). As the display change happens during the saccade onto the target word, the reader never actually sees the preview other than in his or her parafovea. By manipulating the preview, we can assess whether fixation durations on the target word differ, depending on whether the target word, or a similar sounding nonword, was present in the parafovea.

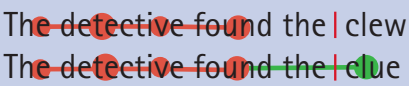


Figure 12. Preview and display change to target word after the reader's gaze crosses the invisible boundary.

Box 3.

Investigating Reading Longitudinally: OPeRA and PLAiT

What are the developmental mechanisms underlying reading acquisition and which precursor abilities are needed? Two interconnected longitudinal studies initiated in 2013 will investigate the preconditions and consequences of children's initial reading ability.

The *OPeRA* project *(Orthographic Processing in Reading Acquisition)* focuses on children's use of different orthographic grain sizes during reading development in school from grade 1 to grade 4. The complementary *PLAiT* project *(Prerequisite Language Abilities in the Transitional Phase)* concentrates on the transition from kindergarten to school and investigates which precursor abilities are linked to children's later reading acquisition. By using a similar theoretical framework and identical outcome measures, *OPeRA* and *PLAiT* will be able to provide a unified picture of the processes needed in the initial steps of reading acquisition and their consequences for children's later development in school.

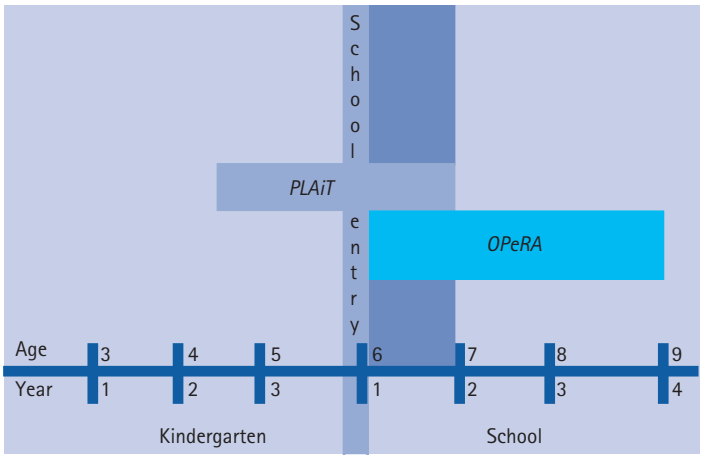
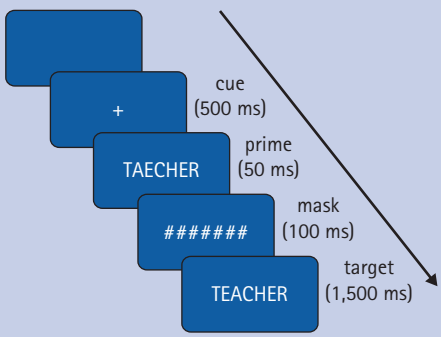


Figure 13. Time frame and overlap of the *PLAiT* and *OPeRA* projects.

OPeRA: Orthographic Processing in Reading Acquisition

Orthographic processing operates using different units, such letters, bigrams, syllables, or morphemes. Which grain sizes readers rely on is thought to vary across languages as well as individuals. In general, it is thought that beginning readers start with smaller grain sizes, such as single phonemes, and by means of chunking proceed to use increasingly bigger units, such as syllables or morphemes.

The *OPeRA* project aims to track the development of orthographic processing in German and to identify the grain sizes used by children at different developmental stages. To this end, we follow 120 students from Berlin elementary schools from grade 1 to grade 4. Data collection will be completed in 2017. A pilot study using the masked priming paradigm (Box 4) provided first insights into the use of morpho-orthographic repre-



The Masked Priming Paradigm

Masked priming is a well-established paradigm to investigate orthographic processing. Different manipulations of the prime can be used, for example, morpheme combinations or letter transpositions, to test the activation of the corresponding units (see Figure 14). Participants are required to decide whether or not the target is a word. The priming benefit relative to a control condition indicates which units are used.

Figure 14. Schematic depiction of the sequence of a trial in the masked priming paradigm.

Box 4.

Key References

Hasenäcker, J., Beyersmann, E., & **Schroeder, S.** (2016). Masked morphological priming in German-speaking adults and children: Evidence from response time distributions. *Frontiers in Psychology, 7*:929. doi:10.3389/fpsyg.2016.00929

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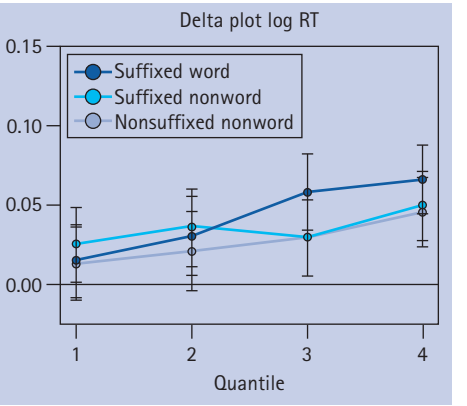

Figure 15. Morphological priming effects for children in different response time quantiles (adapted from Hasenäcker, Beyersmann, & Schroeder, 2016).

sentations by children. Children activate orthographic representations of morphemes *(quick),* regardless of whether it is primed by a suffixed word *(quickly),* a suffixed nonword *(quickify),* or a nonsuffixed nonword *(quickach).* Moreover, analysis of the response time distribution partitioned into quantiles showed that the activation happens even in very fast response times (see Figure 15). This finding indicates the very early and automatic use of morphemes in the elementary school years.

The results from the pilot studies and preliminary analyses of the longitudinal data from the *OPeRA* project offer important new insights into the developmental trajectories of the use of different reading units, especially graphemes, syllables, and morphemes. After completion of the data collection in summer 2017, the longitudinal data set will be analyzed to examine precursor abilities and interindividual differences that influence the progress of the modes of processing in German reading acquisition. Several papers on the longitudinal perspective are planned to appear by the end of 2017.

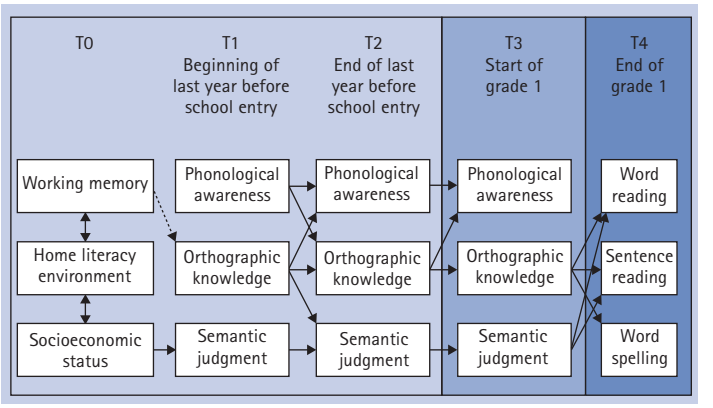

Figure 16. Relationship between linguistic variables and children's later reading ability.

PLAiT: Prerequisite Language Abilities in the Transitional Phase

The longitudinal *PLAiT* project aims at filling the gap between language acquisition studies in early childhood and reading research at school age. *PLAiT* investigates the cognitive development of children in the transitional phase between kindergarten and school. This allows us to relate the development of orthographic representations to the general dynamics of language acquisition.

In this project, the same group of children (ca. $N = 90$) was tested every 6 months for two and a half years, from the 2nd year of kindergarten until the end of grade 1 of elementary school (age 4–7 years). At each measurement point, we assessed children's phonological, orthographic, and semantic abilities.

Data collection was completed in summer 2016. At present, we are about to publish first results focusing on the predictive utility of different linguistic variables for children's later reading acquisition. For example, Figure 16 shows the contribution of children's phonological, orthographic, and semantic skills at different testing points to their ability to read and spell words and sentences in grade 1.

Results demonstrate that early orthographic knowledge is a key predictor for reading and spelling abilities at the end of grade 1. In particular, children's early phonological skills seem to facilitate the build-up of high-quality orthographic representations, which are in turn related to children's later reading ability. In further publications, we will zoom in on children's developmental trajectories in the phonological, orthographic, and semantic domains separately. Taken together, these results will allow us to provide a comprehensive picture of the children's lexical development and its connection to later reading acquisition.

Externally Funded Projects

In the years 2014 to 2016, we were able to obtain external funding for several additional projects including the *MusiCo*, the *ERIC*, and the *Morpheme* project. Each project focuses on a different aspect of children's reading development and complements the core projects of the REaD group.

MusiCo

MusiCo is a longitudinal project funded by the Rat für Kulturelle Bildung and the Stiftung Mercator (2014–2017). It investigates transfer effects of musical training on cognitive and reading development during the transition from preschool to primary school. Recent findings suggest that there is a positive relationship between diverse language and music skills. However, this evidence is largely correlational and does not allow causal interpretations. Experimental studies indicate transfer effects from musical training to specific language skills (e.g., phonological awareness), but evidence is still scarce and rather fragmented. *MusiCo* evaluates longitudinally a broad range of competencies from both language and music to determine the central variables that cause and explain transfer effects from one domain to another. In this study, $N = 200$ children were assigned to three different groups in an experimental pre-post-follow-up design, including an intervention group (music training), an active control group (language training), and a passive control group (no specific training). Before and after the training, a wide range of experimental and standardized measures were used to assess different musical and language processing skills. Results showed significant short-term transfer effects from one domain to another, both from pre- to postintervention as well as within-domain training effects. For example, children in the music training group showed an improvement in their phonological awareness comparable to the language training group (see Figure 17). In addition, children in the music training group showed a significantly higher increase in rhythm skills than both active and passive control groups. These findings suggest that music training supports the development of music skills and promotes the development of preliteracy skills as effectively as language training in preschool children.

Other analyses focus on the interrelationship between music and language skills on different hierarchical levels (Cohrdes, Grolig, & Schroeder, 2016) and how to assess print exposure in kindergarten children (Grolig, Cohrdes, & Schroeder, in press). Next, we will follow up all children after they enter primary school. This will allow us to investigate whether musical training in kindergarten also has long-term effects on children's early reading skills. Data collection is expected to be completed in summer 2017. First results will be published in 2018.

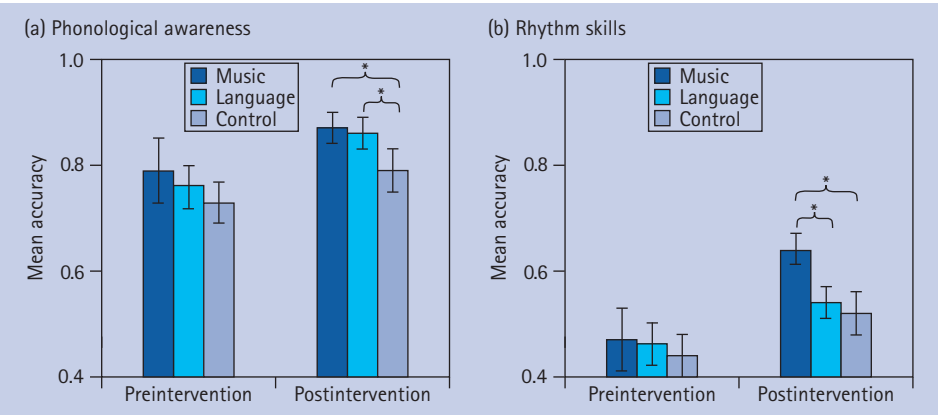

Figure 17. Pre- and posttest performance in language and music skills in the three experimental groups.

ERIC

ERIC is a collaborative project between the MPRG REaD and the Institute for Educational Progress (IQB) and is funded by the German Ministry of Education and Research (2015–2017). The aim of the project is to model the cognitive processes that underlie reading performance in 4th-grade children and to investigate how different teaching methods influence the development of these underlying mechanisms. Thus, our goal is to provide an insight into the kinds of instruction that result in the most stable learning achievements in primary school children.

ERIC comprises a sample of 60 participating 4th-grade classes (N = 800 children) recruited from several federal states. Students took part in a computer-based assessment of their reading processes (T1), which was repeated after 3 months (T2). At T2, students additionally took part in a national assessment encompassing the domains of reading comprehension, listening comprehension, and orthographic proficiency. At the same time, teachers of the participating classes provided evaluations of their students' proficiency in specific reading processes. Teachers also participated in an online logbook, describing their teaching techniques and the learning opportunities provided to their students over a 3-month period. These entries document the amount of time dedicated to specific tasks and exercises, content and methods of German lessons, and an evaluation of the quality of tuition provided.

Data collection was completed in summer 2016. Results from the main study are expected to be published in 2017. However, results from an extensive pilot study (N = 200) show that both spelling and reading comprehension performance are primarily determined by individual differences in the efficiency of lexical, word-level processes (see Figure 18). Lexical-level processes are, in turn, strongly influenced by the home literacy environment and word knowledge. These results emphasize the importance of reading opportunities for growing vocabulary size, which determines performance in the key literacy skills of reading comprehension and spelling.

Our findings demonstrate the importance of lexical processes for reading comprehension and spelling performance, which are primarily driven by reading experience and vocabulary knowledge. In subsequent analyses of the data collected during the main study, we will focus on integrating student performance, teachers' diagnostic competence, and the availability of learning opportunities. The goal of the study is to build a comprehensive picture of children's learning processes over the course of the final 6 months of the 4th grade.

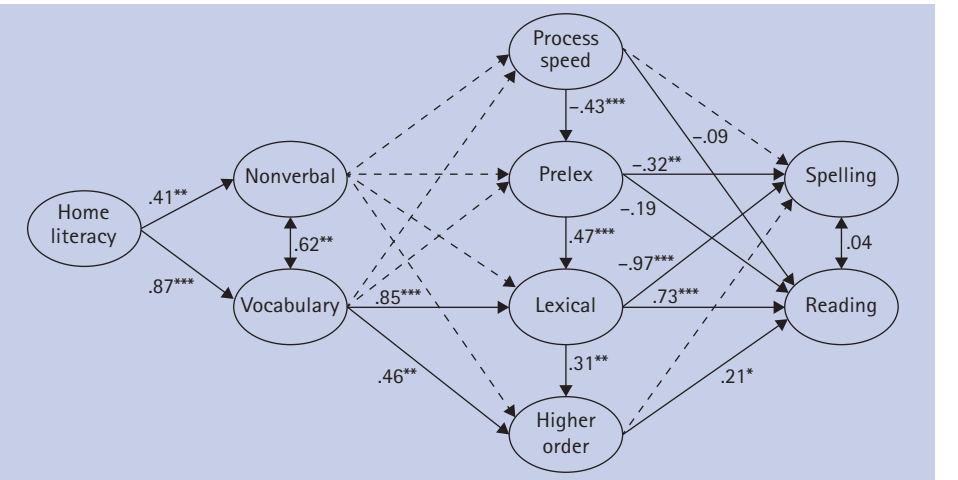

Figure 18. Relationship between reading on different hierarchical levels to children's reading and spellings skills.

Morpheme

Morpheme is a collaborative project between the MPRG REaD and the Laboratoire de Psychologie Cognitive at Aix-Marseille University, funded by a joint grant from the German and French Research Society (DFG-ANR, 2016–2018). This project investigates the development of reading skills longitudinally and cross-linguistically using a combination of methodologies from experimental cognitive psychology, computer science, and education. In particular, we seek to determine *how* and *when,* during reading development, morphological knowledge (knowing that "teacher" consists of two morphemes: the stem "teach" and the affix "er") becomes incorporated into the French and German reading systems. Thus, our research aims to provide important insights into how language-specific characteristics may influence reading acquisition and development. The empirical data will also be used to evaluate and further develop extant theories of reading and their computational implementations.

Morpheme comprises a sample of 240 German and French children ($N = 120$ in each country) in 2nd grade (T1), recruited from state schools in Berlin and Marseille. At T1 (winter 2017), which is currently in process, children perform several computer-based tasks that tap language and reading processes (e.g., aural and visual word recognition, reading aloud). Stimulus materials for these tasks were carefully constructed for cross-linguistic comparison. Children are further assessed on standardized tests that are typically used to measure general linguistic and cognitive processing skills. The same children will be followed up in a longitudinal fashion in 3rd and 4th grade and assessed on the same tasks. Data collection for T2 and T3 will take place in winter 2018 and 2019, respectively. German and French adult participants, who will serve as a control group, will also be tested on the same tasks.

Results from the main study are expected to be published in 2019 to 2020. However, preliminary findings from the German children at T1 suggest that children in 2nd grade are already able to decompose morphologically complex strings of sounds into their constituent morphemes. This was observed in an aural word recognition task (see Figure 19), where children were slower overall in recognizing a string of sounds as a nonword when it contained a stem (e.g., teachness or teachnass), compared to when it did not contain a stem (e.g., teaphness or teaphnass).

The goal of the *Morpheme* project is to investigate the processes that are involved when French and German children learn to read morphologically complex words, which comprise the vast majority of words in both languages. Thus, the findings from this project will offer the potential to develop new evidence-based programs of teaching instruction in both France and Germany. Our aim is to contribute to a wider conversation between academics and practitioners in the pursuit of developing a sound and effective literacy strategy in both countries.

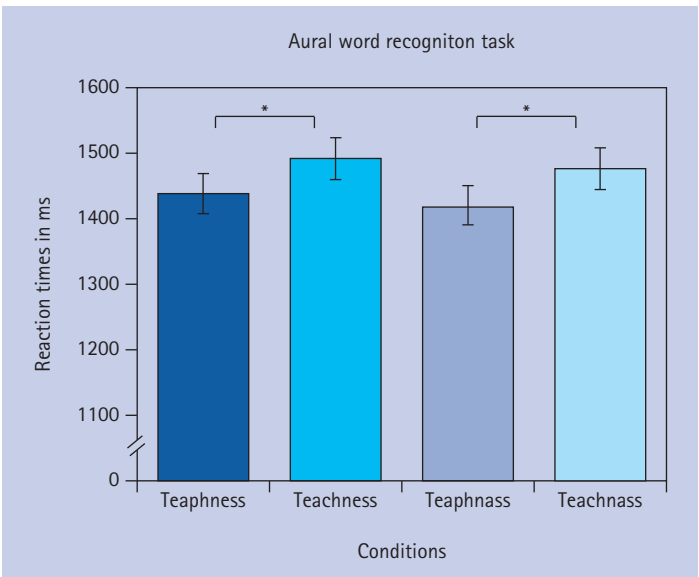

Figure 19. Results from the aural word recognition task in the *Morpheme* project.

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(last update: Spring 2017)

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