Photo: Nina Lüth

Letter by Letter

Children learn to speak simply by imitating what they hear, but only very few learn to read and write without some instruction. **Sascha Schroeder** and his *REaD* research group at Berlin's **Max Planck Institute for Human Development** are investigating just how this works. Through their research, they are creating the basis for effectively supporting children with reading problems.

TEXT **PETRA MIES**

Mia was delighted with her birthday present." Then: "Tina kicked the ball across the field." Then: "The dog was furious because the goose had bitten him."

Letter by letter, word by word, Zoe reads the sentences that flash up on the screen in front of her. By clicking the blue button on the input device she holds in her right hand, the girl herself determines when a sentence has ended and the next one appears. The elementary school student from Berlin has her chin on a chin rest, something she has only ever seen before at the optician. Her head must remain as still as possible. Her pupils, on the other hand, must move. A camera records exactly where Zoe looks when she reads and how she progresses through the sentences. Eye movements are of great interest in the test lab at Berlin's Max Planck Institute for Human Development.

"Great!" says Sascha Schroeder, praising the seven-year-old. "You read very quickly for your age." Zoe beams, proudly stating: "I love reading!" Schroeder and his colleague Simon Tiffin-Richards also have some very different young test subjects in their longitudinal eye-tracking study. Schroeder stretches out his arms: "The spectrum of reading speed is huge, some children look at each word umpteen times." Zoe completes the test, scheduled to last as long as a school lesson and consisting of 96 sentences and short pauses, in just 20 minutes. Less able students take 80 minutes.

ONE IN FIVE ADULTS CAN'T UNDERSTAND SIMPLE TEXTS

Why is that? How exactly do children learn to read? What subprocesses are relevant to written language acquisition? And how important are verbal skills in transferring from the spoken sound to the written letters and vice versa? Schroeder and his six-person research group called *REaD* (Reading Education and Development) aim to find the answers to these and other questions in a number of studies they are carrying out. >

How is reading internalized? The letters in this word game, at least, can be eaten ...

Since the middle of last year, Sascha Schroeder's team has focused on a topic that, up until now, hasn't received enough attention in Germany. With disastrous personal and social consequences, believes the group leader. According to Schroeder, one in five adults in Germany can't understand simple texts. And these aren't just individuals from challenging social backgrounds or people whose first language isn't German. Problems arise across all social strata.

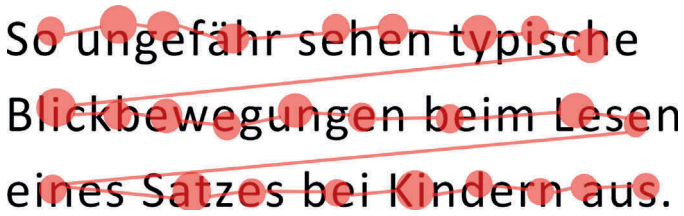
"In our modern information society, individuals with weak reading skills are relegated to the margins," says Schroeder. "For the people affected, this is a disaster that causes them great shame and social isolation. Added to this is a huge economic cost, as they often don't have access to the working world." Not forgetting the political dimension: "The great thing about reading is that it provides enlightenment at a personal level. A person who can read can acquire information independently."

Schroeder sees the vicious cycle that can occur. A person who finds reading difficult will often avoid it. "It's stressful, it's exhausting, so what does a person do? Nothing." The result is a build-up of negative effects. "One thing is very clear: the only way to learn to read is by doing it."

The scientist believes that even the most attractive reading corners are pointless if children haven't mastered the cultural skill of reading. "Anyone who can't read can't participate." The reading support programs set up after the first PISA studies did little to change the situation. In Schroeder's opinion, they are often largely ineffective, as the processes on which reading is based are still unclear. "That is our basic premise: before continuing to support reading, it would be better for us to take a step back and look at the cognitive mechanism behind it." He says that basic research first needs to be carried out before practices can be improved.

In order for support projects to really bear fruit in the future, the psychologist, linguist and musicologist believes that much more information is needed. To date, there has been a lack of such relevant knowledge here in Ger-

Photo: Nina Lüth



left page | It looks like a visit to the optician: The eye-tracking device follows and records the eye movements of the young test subjects while they read.

above | Beginning readers make their way letter by letter and have sometimes forgotten the beginning of a long word by the time they get to the end of it. It is a case of taking one step back before they make significant progress as their skills improve. Circle size indicates how long the eyes pause on words.

many. The situation is different in English-speaking countries, but the results can't be compared, as the written language has very specific characteristics in each case. The transfer of the written word into spoken language also differs between languages. The orthographic code is more difficult to crack in English than it is in German. In short, researchers must have a basic knowledge of how written language – here specifically German – is acquired before they can effectively help children with reading difficulties in the future.

The starting point seems to be clear. "Writing is solidified language," explains Schroeder. "Reading is transforming visual information into linguistic information. The spoken word, the sound, flies away and spreads out over time. The written word, on the other hand, is fixed and is spatially organized." Transforming these two dimensions into one another is one of the most complex cultural achievements in history. Finding out what obstacles this involves is at the heart of the *REaD* project.

Children generally learn to speak solely by interacting with their parents and others. According to the research group leader, the current research assumes that the better developed a child's verbal skills are, the easier it is for him or her to learn to read. However, reading and writing don't just come to them in the same way that speaking does. They need to be taught how to assign the speech sounds they know to the correct sequences of letters. And they often need to practice for years until they understand just how it works. The fact that the German word for "bee" (Biene) needs an "ie", whereas "tiger" (Tiger) is written with just an "i", though the sound is the same, can't simply be deduced. Sascha Schroeder points out that many people later forget how difficult it is for beginners to solve the puzzle of sounds and letters.

BACK AND FORTH ON THE WAY TO THE END OF THE SENTENCE

For anyone learning to read, conquering the written world is an arduous journey, and progress is erratic. "We think our eyes move over the lines in a nice, even manner, but that isn't the case. Instead, we jump across a text in so-called saccades." Our eyes pause in between the jumps and, during this time, we process the information that we have read. These pauses are necessary because only an extremely small part of our field of vision – also known as the foveal area – is sharp enough to be able to identify letters and words. This vision cone isn't round like the beam of light from a flashlight, but is somewhat bigger and wider to the right in the direction of reading. This allows us to guess what the eyes are about to read. In the area to the left, the outlines tend to be less distinct.

However, not all languages read from left to right and top to bottom. Arabic, for instance, is read from right to left. It is convenient, therefore, that a reader's sharp field of vision always expands in the direction in which a text flows, depending on their native language. This means that it expands to the left in Arabic-speaking people. It's just a matter of practice.

Beginners don't know anything about reading direction. They first have to learn that writing arranges language in lines and separates words from one another. Compared to experienced readers, they move their eyes across the text in two different ways. "Initially, children tend to read sequentially. They work through a text letter by letter, much in the same way as you would cut a sausage into slices," says Schroeder. "Word length is therefore an important factor for beginning readers."

It is precisely at the beginning that the struggle to move from word to word requires effort and time, with the result that children have forgotten the beginning of a word by the time they have reached the end of it. They then need to find their way back to the start of the word and fixate on it again. On average, children perform two to three fixations per word, as it's called in linguistic jargon: "That's why we observe their erratic eye movements."

Skilled readers approach the issue in a more practiced and thus more holistic way. They also jump around, but mostly in a forward direction, namely to skip words. Experienced adults ignore 20 to 30 percent of all words. And, in the case of the words they do read, they don't go through them letter by letter. They rarely need to look at a word more than once to process it. The trained eye flits over the lines much faster and the experienced individual reads fluently. >

Graphic: MPI for Human Development

Real or made up? Adults usually have no problem deciding whether "Onschatt" is really a word. But how long does it take the young test subject of research group leader Sascha Schroeder to do this? On the laptop, she helps Baldrian, the word wizard, restore order in the wake of the chaos caused by the word blitz.

Reading performance frequently declines as people age, partly due to failing eyesight. Yet older recipients still don't jump around in the texts as much as children do. Do people over the age of 65 'unlearn' how to read? The researcher's answer to this is an emphatic "No." He talks about phases. "The difficult learning phase lasts up to the age of 16. This is followed by the stable plateau phase, which extends beyond middle adulthood. In old age, there is something of a decline again."

But back to the beginners. One of the fundamental issues being investigated by the team in Berlin relates to the changes in the speed and intensity of eye movements during reading development. As Schroeder says: "Is it related to the fact that children's eyes are still developing, or that children are constantly improving linguistically?" And also: "What controls eye movements? How do the eye movements of children with reading difficulties differ from those of children who don't have reading difficulties?"

Schroeder hopes that studying eye movements during reading will also be of practical use. Knowledge about eye movements helps uncover problems with reading. According to Schroeder, in the 1970s, it was still believed that poor readers had problems primarily with the coordination of their eye movements. At that time, it was assumed that, in children with reading disorders, the system controlling the movement of the eyes wasn't yet mature – that is, not sufficiently developed.

FINNISH CHILDREN FIND IT EASIER TO LEARN TO READ

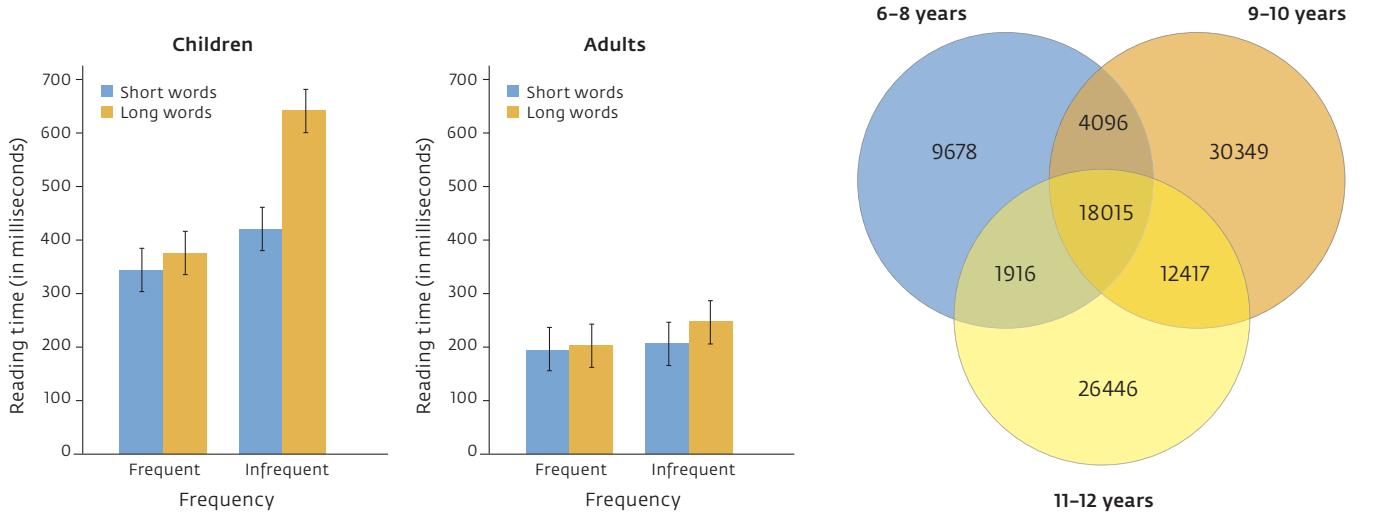
"New research results refute that," explains Schroeder. "Children with reading problems actually do have unusual eye movement patterns, but that isn't the cause of their problem. Rather, it is more likely to be a consequence of their linguistic deficits." One benefit of the eye-tracking approach is thus that it has clarified a completely erroneous belief. Eye-tracking studies are also helping to answer the question of what linguistic information is actually used during the reading process.

The longitudinal eye-tracking study focuses on the traditional elementary school age at which reading skills develop most rapidly. As the eye is an organ common to all human beings, an international comparison also reveals interesting results. If the eyes and their fine-tuning develop at the same speed in all children, a study comparing eye movements in different languages would help to separate the effects of visual and linguistic influences. To explore this, English and Finnish children read translations of the texts developed by Schroeder's team in Berlin. It's important that the level of difficulty, for example the ratio of known and unknown words, and of long ones and short ones, be very similar in all three languages.

Transparency is one of the keywords in the international comparison, so: how directly does a language transfer its sounds to letters? According to Schroeder, German lies somewhere in the middle. English is the most complicated, and Finnish is the easiest because the language is written the way people speak it. Because of this, it makes sense for children in the UK to be sent to school at the age of five, and also to be introduced to reading before starting school, explains Schroeder. "In Germany, first-graders can often read after six months, or at the latest by the end of the school year; in the UK, it takes much longer." Researchers haven't yet definitively figured out the different rates of progress and the reasons for them.

In their study on the eye movements of child readers, the researchers

Photos: Nina Lüth (2)



Eye-tracking reveals all: The bar charts (left) show the time that children and adults take to read various words embedded in sentences. The words (short = four letters, or long = eight letters) appear with varying degrees of frequency in German (infrequent versus frequent). It turns out that, among children, the reading times for short and long words don't differ if the word is familiar to them; this isn't the case for words that they seldom encounter. Among adults, this effect is no longer apparent. The circles (right) refer to the number of words collected for the different age groups in *childLex*. There are large overlaps between all the groups, but around 40 percent of the words are used only in a certain age group.

in Berlin discovered that children find it easier to read words that they already know, irrespective of the language. To find out more about how children try to read known and unknown words differently, the researchers first had to gain an overview of the children's vocabulary: which words, phrases and grammatical constructions do German children know?

German children have an average vocabulary of 5,000 words when they start school. Schroeder explains that, at a minimum, they should have a vocabulary of 20,000 words by the time they leave school. "This means that we have to learn 15,000 words by then. Due to the sheer lack of time, this may not occur during school hours only." It has been proven that children expand their vocabulary mainly through books they read outside of school. Or don't.

Analyzing the language in children's books also provides information about the words that children may know. This is exactly what the Berlin team, together with the Berlin-Brandenburg Academy of Sciences and Humanities and the University of Potsdam, did. One year later, the partners are now presenting the relevant data for Germany for the first time. *childLex* is the name given to the collection of words and linguistic constructions that children encounter in age-appropriate books.

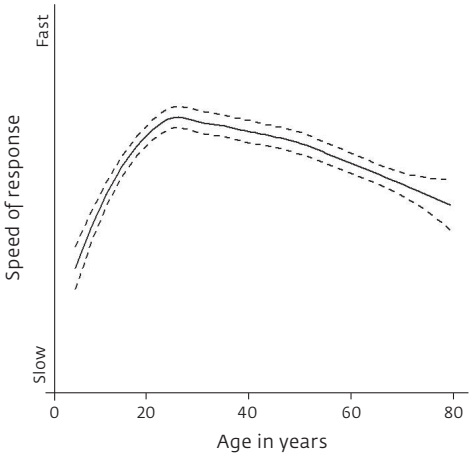
ON THE TRAIL OF A VOCABULARY WITH *CHILDLEX*

It was a huge undertaking. The researchers analyzed around 10 million words in 500 children's books. They assigned a syntactic category to every word, classifying it, for example, as a noun, verb or adjective. They counted the frequency with which particular words are used in books for different age groups. As Schroeder says, it's easy to see that words like "pirate", "elf" or "dragon" belong in a child's vocabulary. "But how do children react to conjunctions like 'therefore' or 'thus', which introduce inferences? And do books that are intended for girls differ in their linguistic complexity from boys' books?"

The *childLex* database of vocabulary – linguists refer to it as a corpus – distinguishes between three age groups: 6- to 8-year-olds; 9- and 10-year-olds; and 11- and 12-year-olds. The analysts also paid attention to the way in which words in books change between the individual groups. Schroeder cites a few examples: "From an early age, children find it easy to understand everything to do with time, such as 'quickly', 'after that' and 'before that' – that all works well." They find it more difficult to deal with causal relationships and consequences for the future. "For instance, German beginners often confuse 'therefore' with 'which is why' [the respective words in German are 'deshalb' and 'weshalb'] and struggle with the difference."

childLex has now helped to answer these questions. The authors of the books play a crucial role in this regard. They choose a language that they believe corresponds to a level that is understood by the relevant target group. Or they deliberately use constructions, such as inferences, so that children become familiar with them. In this way, authors are fundamental in determining their readers' vocabulary.

Schroeder sees the corpus as the input that is passed on to adolescents. Similar studies have already been done for Spanish, French and English. However, he notes: "Compared with these other languages, German has by far the most word forms." Each verb alone can be conjugated in at least 13 different variants. And if something new needs to be named, German can quite happily coin new terms from existing words. >



Age takes its toll: The diagram shows how the speed of response in a lexical decision task changes over a person's lifetime. Up to the age of 25, people get faster and faster at this task; the speed of response subsequently declines steadily, albeit at a very slow rate.

The German word for "nurse" [Krankenschwester, literally "sister of the sick"] is a case in point. Viva the compound noun!

The *childLex* project has now been completed and an online database is available. Interested parties are free to use the website. It also provides information about the frequency with which certain words appear in children's books. Books frequently contain not only function words like "and", but also words like "mom" and "dad".

The children's corpus also provides important material for a further study. In the *DeveL* (Development Lexicon) project, the researchers selected 1,200 words from *childLex* with different linguistic properties, such as frequency, word length and number of syllables. In their research, they observe how long children in the second, fourth and sixth grades take to read them. Another important area of interest is the mistakes that they make when reading them. The researchers want to figure out the determining linguistic criteria for reading speeds at specific ages.

At the same time, the team also asked young and older adults to read the words in order to explore how reading changes over a person's lifetime. "Of course, adult word recognition models already exist," Schroeder clarifies. "But to date, no research has been conducted on how development reaches that stage. We need this empirical data, which will map the path from childhood to adulthood."

The older the reader, the bigger the linguistic units become. While beginning readers make their way from one letter to the next, more advanced readers process words in syllables or in even larger units. According to some theories, word lengths initially determine reading speed to a very great extent, though this does decline. The frequency with which a word is used then becomes an increasingly important factor in reading time.

DO MAGIC WORDS LIKE "GLUSS" AND "BRABBEL" REALLY EXIST?

DeveL will explore whether this is true. One task in the *DeveL* project involves asking children and adults to read words as quickly as possible. In a second task, the test readers must decide as quickly as possible whether a word on a computer screen is correct and really exists or whether it is actually a nonword. Right key, word is correct. Left key, word is wrong – words such as "Gluss" and "Brabbel".

If children are taking the test, the newly coined words are known as "magic words": it's important that the research be fun for the children. The researchers therefore explain to them that a word blitz has smashed into the castle of the word wizard Baldrian. Everything is in chaos and, on the computer, the children are supposed to help him to restore order. The response times in the lexical decision task provide information about how common words are in particular age groups. The series of studies isn't yet complete, so the team still has plenty of work ahead of it.

Zoe, on the other hand, has completed her test. She and her mother quickly leave the Berlin institute by the side exit. She is smiling. Perhaps because she has a good book waiting for her at home. ◂

TO THE POINT

- **In contrast to the spoken word, written language doesn't develop without instruction and practice. One in five Germans doesn't have good written language skills or can't write at all.**
- **Early beginning readers, on the one hand, process texts letter by letter and word by word. In doing so, however, they fixate on words several times, with the result that their eyes jump around in the text. Advanced readers, in contrast, also jump through a text, but they often skip words.**
- **Research findings about how children's eyes move when reading provide starting points for optimizing support programs for children with reading difficulties because they reveal in detail where the children have difficulties.**
- **The greater a child's verbal skills and word knowledge, the easier it is for him or her to transfer sounds to letters and words (and vice versa) when acquiring written language skills.**

GLOSSARY

Fixation: A pause in eye movement.

Corpus: A sample of speech, such as a collection of words; a corpus provides the basis for linguistic analyses.

Saccade: A fast movement of an eye.

Semantic: Relating to semantics, that is, the meaning of letters and words.

Syntactic: Relating to syntax, that is, the structure of a sentence. Words can be classified into syntactic categories. This means they can be ordered according to their function in a sentence, so as a noun, verb or adjective, for instance, or as a subject, verb or object.

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