

# Are reading tasks relevant?

## Comparing eye movements of children with and without reading disorder in silent and oral reading.

### A pilot experiment

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## Introduction

Although eye tracking has found increasing use in psycholinguistic reading research in recent decades (for overview see [1]), there is a lack of combined studies relating to the manifestation of eye movements in different reading modes with respect to reading skills and reading acquisition.

**Reading mode** (silent and oral reading, SOR) has already been investigated in competent adult reading (e.g. [2, 3]). Persons reading orally showed smaller saccade amplitudes and longer fixation durations, an increased number of regressions and an increased reading time compared to reading silently (summary in [4, 5]). A study with typical developed English-speaking children found higher numbers of fixations and longer fixation durations for oral compared with silent reading [6]. However, the transferability of these results into German-speaking readers is limited, as studies have shown that eye movement parameters differ during reading acquisition depending on orthographic consistency [7, 8].

**Reading skills** have been taken into account by numerous studies investigating eye movements of children with reading disorder (RD) and with typical reading development (TD). Summarised the data show higher numbers and enhanced durations of fixations, an increased probability of regressions and smaller amplitudes of saccades [7-13].

A **combined view** on both reading mode and reading skills is provided by only one single study on adolescents: Showing emphasised differences in eye movements in SOR than less competent adolescent readers, the authors suggest effects of reading skills on silent reading but limited on oral reading [14].

Because of the lack of combined studies about the manifestation of eye movements in SOR with respect to reading skills of children during reading acquisition in German, we address the following question: Are there statistically significant differences in total reading time and eye movement parameters between children with TD and RD depending on reading mode in fourth grade in German?

## Method

Eye Movement Recordings		Participants	
<b>Materials and Design</b>		<b>Typical reading development (TD, n = 44)</b>	
Each participant read one text orally and one text silently. SOR texts are age-appropriate, matched for length and have nearly identical orthographic frequency (see table on the right).		Reading disorder (RD, n = 9)	
<b>Apparatus</b>		<b>Statistical analysis</b>	
Tobii Remote Eyetracker T120 Data rate: 120 Hz Eye tracking technique: bright and dark pupil tracking Screen size: 17" TFT		Independent t-tests	
Gaze plot of an RD during oral reading		Gaze plot of an RD during silent reading	
Orthographic frequency (mean frequency class) [15] reading difficulty index LIX [16]		Gender & age in years	
Oral Reading: 7,96 Silent Reading: 7,82		n = 18 female, n = 26 male Mean age: 10,05 (0,41)	
Oral Reading: 34,60 Silent Reading: 34,00		n = 4 female, n = 5 male Mean age: 10,36 (0,56)	
TD		Reading skills	
Oral reading		Mean T-Score: 48,57 (5,17)	
Silent reading		Decoding (SLRT-II [17]) & Comprehension (ELFE 1-6 [18])	
RD		Cognitive abilities	
Oral reading		Mean T-Score: 55,52 (5,17)	
Silent reading		Nonverbal CFT1-R [19]	

## Results

Comparison between SOR (see figures)		Comparison between reading skills (see tables)	
Depending on SOR within the groups, the results show statistically and practically significant differences between SOR for TD in the majority of parameters ( $p < .05$ , $d > .2$ ) with the exception of regressive saccade amplitudes and number of regressive intra-word saccades ( $p > .05$ ). In contrast, RD showed only differences in SOR in restricted number of eye movement parameters. Differences were found in reading duration as well as number of progressive and regressive inter-word saccades. Other parameters showed no differences in eye movements in both tasks in RD ( $p > .05$ ), but in all of these parameters effect size indicated a practically significant difference ( $d > .2$ ).		Depending on reading skills, the comparisons in SOR between TD and RD showed statistically and practically significant differences in some parameters ( $p < .05$ , $d > .2$ ). In oral reading, there was no difference in fixation duration ( $p > .05$ ) but in number of fixations ( $p < .05$ ). In addition, differences in amplitudes and number of progressive intra- and inter-word saccades were found ( $p < .05$ ). In contrast, in silent reading, the comparison only showed differences in number of fixations, fixation duration as well as number of progressive and regressive intra-word saccades ( $p < .05$ ). In addition, regressive saccade amplitudes and number of regressive inter-word saccades showed no differences in SOR ( $p > .05$ ).	
<b>Text reading duration</b>		<b>Progressive saccades</b>	
TD: $p < .001^{***}$ , $d = 1.024$		intra-word: $p = .05^*$ , $d = .320$	
RD: $p = .043^*$ , $d = .872$		inter-word: $p = .134^{ns}$ , $d = .921$	
<b>Number of fixations</b>		TD: $p < .001^{***}$ , $d = .630$	
TD: $p = .004^{**}$ , $d = .471$		RD: $p = .003^{**}$ , $d = 1.736$	
RD: $p = .302^{ns}$ , $d = .377$		TD: $p = .002^{**}$ , $d = .539$	
<b>Mean duration of fixations</b>		RD: $p = .235^{ns}$ , $d = .775$	
TD: $p < .001^{***}$ , $d = 1.220$		intra-word: $p = .891^{ns}$ , $d = .049$	
RD: $p = .565^{ns}$ , $d = .240$		inter-word: $p < .001^{***}$ , $d = 1.418$	
<b>Oral Reading</b>		intra-word: $p = .178^{ns}$ , $d = .207$	
Parameter		inter-word: $p = .002^{**}$ , $d = 1.486$	
Text reading duration		TD: $p = .675^{ns}$ , $d = .060$	
Fixations		RD: $p = .679^{ns}$ , $d = .142$	
Number of fixations		inter-word: $p = .656^{ns}$ , $d = .066$	
Mean duration of fixations		TD: $p = .763^{ns}$ , $d = .104$	
Progressive saccades		RD: $p = .763^{ns}$ , $d = .104$	
Intra-word: number		inter-word: $p = .763^{ns}$ , $d = .104$	
Intra-word: amplitude		inter-word: $p = .763^{ns}$ , $d = .104$	
Inter-word: number		inter-word: $p = .763^{ns}$ , $d = .104$	
Inter-word: amplitude		inter-word: $p = .763^{ns}$ , $d = .104$	
Regressive saccades		inter-word: $p = .763^{ns}$ , $d = .104$	
Intra-word: number		inter-word: $p = .763^{ns}$ , $d = .104$	
Intra-word: amplitude		inter-word: $p = .763^{ns}$ , $d = .104$	
Inter-word: number		inter-word: $p = .763^{ns}$ , $d = .104$	
Inter-word: amplitude		inter-word: $p = .763^{ns}$ , $d = .104$	

## Discussion

**Results.** To the best of our knowledge, this study is one of the first to investigate SOR and eye movements in children, i.e. individuals in reading acquisition, with and without reading disorder. The results of TD indicate different characteristics of eye movement parameters depending on reading mode, corresponding with a study of adolescents in German [14]. In contrast, the data of RD show only isolated differences. This discrepancy between TD and RD in eye movements, except regressions, could indicate an adaptation of TD to demands of reading strategies as a function of reading mode, but this is not similarly performed by RD. Differences depending on reading skills, i.e. comparing TD and RD, are more distinct in oral than in silent reading.

**Limitations.** It has to be taken into account that even with cautious construction of extensively matched texts, these could contain different linguistic requirements and therefore qualitative differences may arise [6, 14]. Therefore, the knowledge gained in this pilot experiment needs further examination and differentiation. The long-term study BLab (see QR-Code) at the Humboldt-Universität zu Berlin represents a suitable basis for this due to its sample size.

**Practical relevance.** In the diagnosis of decoding ability during reading acquisition, analysis of oral reading dominates [20]. The results reported here point out to the differences in eye movements between SOR and between TD and RD, indicating differences in adaptation of reading strategies. Reading instruction and intervention should target abilities in both reading modes and carefully facilitate the transition from oral to silent reading to support RD.

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