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Development of the perceptual span in reading: A longitudinal study

Anja Sperlich, Johannes Meixner, Jochen Laubrock *

Department of Psychology, University of Potsdam, 14476 Potsdam, Germany

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ABSTRACT

The perceptual span is a standard measure of parafoveal processing, which is considered highly important for efficient reading. Is the perceptual span a stable indicator of reading performance? What drives its development? Do initially slower and faster readers converge or diverge over development? Here we present the first longitudinal data on the development of the perceptual span in elementary school children. Using the moving window technique, eye movements of 127 German children in three age groups (Grades 1, 2, and 3 in Year 1) were recorded at two time points (T1 and T2) 1 year apart. Introducing a new measure of the perceptual span, nonlinear mixed-effects modeling was used to separate window size effects from asymptotic reading performance. Cross-sectional differences were well replicated longitudinally. Asymptotic reading rate increased monotonously with grade, but in a decelerating fashion. A significant change in the perceptual span was observed only between Grades 2 and 3. Together with results from a cross-lagged panel model, this suggests that the perceptual span increases as a consequence of relatively well-established word reading. Stabilities of observed and predicted reading rates were high after Grade 1, whereas the perceptual span was only moderately stable for all grades. Comparing faster and slower readers as assessed at T1, in general, a pattern of stable between-group differences emerged rather than a compensatory pattern; second and third graders even showed a Matthew effect in reading rate and the perceptual span, respectively.

* Corresponding author.
E-mail address: laubrock@uni-potsdam.de (J. Laubrock).

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Introduction

Reading is a fundamental cultural skill that is the prerequisite of achievements in many fields. As such, the development of reading is a highly important topic. Whereas different aspects of the reading skill can be measured with coarse granularity using standardized tests, eye movements are generally taken to be the most sensitive measure for the dynamics and microstructure of reading (Huey, 1908; Rayner, Pollatsek, Ashby, & Clifton, 2012). The eye needs to be moved across the line of text because of the steep gradient of visual acuity that limits clear vision to a relatively narrow region around fixation. Thus, parafoveal preview of upcoming text to the right of the current fixation location is considered to make an important contribution to efficient reading performance. The amount of useful preview has been termed the perceptual span and can be measured using the moving window technique (McConkie & Rayner, 1975).

Rayner (1986) was the first to systematically investigate changes in the size of the perceptual span across different age groups. Comparing children in Grades 2, 4, and 6 with adults, he found that perceptual span size increases with age so that even children are capable of extracting basic linguistic information from the parafovea. Häikiö, Bertram, Hyönä, and Niemi (2009) replicated these findings and extended them to Finnish. Sperlich, Schad, and Laubrock (2015) reported a cross-sectional analysis from the first wave of a longitudinal study. They found that development of the perceptual span in German children showed greater increases after Grade 2 than after Grade 1, whereas changes in basic indicators of reading (reading rate, fixation durations, refixation probability, and saccade length) were more pronounced after Grade 1 than after Grade 2, as in a typical learning curve. Due to the delayed onset in the perceptual span, Sperlich and colleagues concluded that the development of the latter begins only after basic reading processes are relatively well developed. The current study is a longitudinal successor to this work. First, we investigated whether these results replicate across cohorts. Second, as a new methodological contribution, we used nonlinear mixed-effects models (NLMMs) in order to model the perceptual span; in particular, we modeled asymptotic growth of reading speed as a function of window size. Third, in longitudinal analyses, we examined the intra-individual stability of observed and predicted asymptotic reading rates and perceptual span size as well as developmental patterns therein, that is, aspects of inter-individual stability. Specifically, we were interested in whether differences between faster and slower readers increase, decrease, or remain stable over 1 year. Finally, the causational relation of perceptual span and phonological decoding skill were addressed by means of a cross-lagged panel analysis.

Developmental patterns in reading research

The assumption of different developmental patterns for reading acquisition presupposes that there is a systematic relation between early readers' initial reading levels and their learning rates. Considering developmental trajectories in skill acquisition, Stanovich (1986) introduced the Matthew effect into reading research. The effect is termed after the biblical verse Matthew 13:12, "Whoever has will be given more, and they will have abundance. Whoever does not have, even what they have will be taken from them." Applied to reading, the Matthew effect relates initial reading skill to the change in reading skill with time and specifically states that the initial reading skill correlates positively with growth rates. Thus, children who enter school with solid prereading skills such as high phonological awareness, a large vocabulary, and good listening comprehension are thought to gain cumulatively more in reading competence than their less well-prepared peers. Group differences in reading skill would increase over time so that, when graphically displayed, the Matthew effect resembles a fan-spread shape. Such a developmental pattern would be alarming because of the adverse socioeconomic future prospects for struggling readers (Duncan et al., 2007; Ritchie & Bates, 2013) and would call for early intervention, for example, a policy to allocate more pedagogical resources to children with an initial deficit. Early reading difficulties indeed constitute a huge problem, with a prevalence of approximately 13% (Martin, Mullis, & Kennedy, 2007; Schreiner, Breit, Schwantner, & Grafendorfer, 2007).

Despite the high attention paid to the Matthew effect in reading research and the empirical support it has received from a number of studies (Bast & Reitsma, 1998, for word recognition; Juel, 1988, for reading time; Klicpera & Schabmann, 1993, for reading speed), empirical evidence is inconclusive, at