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The relation between time spent reading and reading comprehension throughout the life course

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Background: In the present paper, we investigated the association between time spent reading and reading comprehension throughout the lifespan. According to the Matthew effect (or rich-get-richer and poor-get-poorer) model, interindividual differences in reading-related skills between poor and average readers become wider as individuals grow older. Furthermore, the model states that these differences may be caused by different reading habits (i.e., the amount of time spent reading). Less competent readers tend to read less and therefore show less improvement in their reading skills. Competent readers tend to read more and therefore show greater improvement in their reading skills. Therefore, we propose that the correlation between time spent reading and reading comprehension should increase as people grow older.
Method: To test this hypothesis, we analysed data from the German National Educational Panel Study (NEPS). We used data from four cohorts (N = 28,795) with an age range from preadolescence (Grade 5) to later adulthood (>55 years).
Results: Our results showed a medium-sized correlation between leisure-time reading and reading comprehension for students attending secondary school ($\beta \sim 0.20$). Contrary to our expectations, the correlations decreased with age and reached a stable low level ($\beta \sim 0.07$) in adulthood. However, for adults, occupation-related reading predicted reading comprehension ($\beta = 0.13$–0.23).
Conclusion: According to our results, reading should be viewed as a process that changes throughout the lifespan. Furthermore, results and implications from previous studies on the relation between time spent reading and reading skills from research conducted on school students might not be generalisable to adults. With respect to the results of the present study, we might restrict the validity of the Matthew effect in reading to school students and young adolescents.

Keywords: time spent reading, life course, reading comprehension, occupation-related reading, cohort comparison

Highlights

What is already known about this topic

- Positive relation between recreational time spent reading and reading competences in childhood and adolescence (r ~ .3).
- Convincing evidence for Matthew effect in reading in (early) adolescence.

What this paper adds

- This paper analyses four cohorts with ages that range from early adolescence to late adulthood.
- In addition to recreational reading, this paper takes occupation-related reading into account.

Implications for theory, policy or practice

- Low correlations between time spent reading and reading comprehension in adulthood are not consistent with the derivations of the Matthew effect in reading.
- Occupation-related reading becomes increasingly important during adulthood, thus, reading should be viewed as a process that changes across the lifespan.
- Previous results from research on school students cannot be generalised to all age groups.

Reading development is a process that starts in early childhood before formal education begins and continues until young adulthood and even beyond (Alexander, 2005). Although school is the primary authority that teaches school students how to read (Philipp, 2011), extracurricular reading also contributes to individual differences in school students' reading skills (e.g., Anderson, Wilson, & Fielding, 1988; Pfost, Dörfler, & Artelt, 2013). But irrespective of the question of where school students acquire their skills, efficient reading requires practice, and various studies have provided convincing evidence that reading habits (e.g., the amount of time spent reading) promote the development of reading skills (Anderson et al., 1988; Greaney & Hegarty, 1987; Guthrie, Wigfield, Metsala, & Cox, 1999; Mol & Bus, 2011; Pfost et al., 2013; Pfost, Dörfler, & Artelt, 2010). Furthermore, research on the home literacy environment has provided evidence that starting joint book reading activities in preschool-age children – before they begin formal education – is of primary importance for children's oral language and reading skills (e.g., Burgess, Hecht, & Lonigan, 2002; Bus, van IJzendoorn, & Pellegrini, 1995). Although there is strong evidence for the importance of frequent reading in preschoolers as well as in secondary school students, the relation between reading habits and reading skills has been studied in adulthood less often, and findings have seldom been compared across different age groups. Therefore, in the present study, we analysed data from the largest longitudinal multicohort study on education processes and outcomes in Germany – the National Educational Panel Study (NEPS) – to investigate the relation between time spent reading and reading comprehension in different age groups ranging from early adolescence to later adulthood.

Reading as a lifelong process of development

The development of reading skills and reading habits is not limited to childhood or early adolescence; rather, it is a lifelong process. By applying a lifelong learning procedure, Alexander (2005) differentiated three types of reading development: acclimation,

competence and proficiency/expertise. Essential basic reading skills – skills related to decoding and word reading – are learned in the early years: the acclimation stage. In the second stage, the competence stage, knowledge, interest and strategies are significantly transformed (e.g., domain knowledge increases or knowledge is more cohesive in structure), which allows a person to read longer and more complex texts. Finally, in adolescence and adulthood, the proficiency/expertise stage is achieved, where aspects such as critical reading, expert knowledge and deep processing strategies are acquired. However, the increase in reading skills tends to be nonlinear. Among others, Hill, Bloom, Black, and Lipsey (2008) examined the average annual gain in effect size based on nationally normed tests from kindergarten to Grade 12. They showed that the largest development occurs in the early school years (the average effect size from kindergarten to Grade 1 was $M = 1.51$). Whereas in later school years, growth in reading skills in terms of effect size declines, resulting in a stable competence level by the end of high school (average effect size from Grades 11 to 12 was $M = 0.06$; cf. also Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996).

Concerning adolescents' reading habits, empirical results on developmental trends have been shown to be less consistent. Whereas some studies have shown a decrease in volume of reading with age (e.g., McElvany, Kortenbruck, & Becker, 2008; van Schooten, de Glopper, & Stoel, 2004), other studies have provided contrasting evidence. For example, the longitudinal study by Johnsson-Smaragdi and Jönsson (2006) showed that young adults engaged in a larger amount of reading than children. However, past empirical studies have tended to focus on children and school students, failing to analyse trends in and effects of reading habits and especially time spent reading beyond these groups. If we keep in mind that reading is a lifelong process and that frequent reading is important for education and vocation in a globalised society (OECD and Statistics Canada, 2000), it seems to be necessary to gain more knowledge about the differences that exist with respect to the amount of time individuals spend reading and their reading skills across the lifespan by explicitly taking adults into account. A theoretically and empirically sound model that explains the relation between reading skills and time spent reading and the development of these variables across time is the Matthew effect model in reading (Pfost, Hattie, Dörfler, & Artelt, 2014; Stanovich, 1986).

The Matthew effect in reading: Reciprocal effects between reading and reading skills

The idea of a cumulative developmental trend due to reciprocal and self-reinforcing effects has been disseminated widely across several scientific disciplines, including fields such as economy, sociology, politics, psychology and education (Baumert, Nagy, & Lehmann, 2012; Caspi, Bem, & Elder, 1989; DiPrete & Eirich, 2006; Merton, 1968; Rigney, 2010). In short, because of an uneven distribution of opportunity structures and processes of self-selection into these structures, inequalities not only tend to remain stable but even increase with time. The assumption of positive feedback loops is at the core of this model. Adapted to the specific case of reading development, Stanovich (1986) elaborated on a developmental model in which small early differences in reading achievement increase over time as individuals grow older. Thereby, a key element of the Matthew effect model is the assumption that cumulative differences in reading are caused by differences in reading habits, especially the time individuals spend reading. Extracurricular and self-initiated reading fosters the development of reading skills. In turn, reading skills positively affect

reading motivation and time spent reading or reading volume, both of which foster the development of reading skills (Stanovich, 1986). In a very simplified manner, this means that those who read a lot become increasingly superior readers, whereas those who read less remain readers with low reading skills. This pattern has often been labelled the 'virtuous circle of reading' or the 'vicious circle of nonreading' (Organisation for Economic Cooperation and Development [OECD], 2010; Pfost et al., 2010; Pfost et al., 2013), highlighting the self-reinforcing reciprocal character of this developmental mechanism. Ultimately, this process should lead to a twofold fan-spread effect; on the one hand, we should observe increasing individual differences in reading skills with age. On the other hand, in addition to the first consequence, we should also observe increasing individual differences in the time spent reading with age. This means there should be a clearer differentiation between people in older age groups on these variables (e.g., people who are good readers and also read a lot vs people who have poor reading skills and read less). In younger age groups, this differentiation is not as distinct because people are at the beginning of their reading careers (Mol & Bus, 2011). As a consequence, with regard to the Matthew effect in reading, we can expect higher correlations between reading skills and the amount of time spent reading in older people in comparison with younger people (Mol & Bus, 2011).

Concerning the empirical evidence, only a few studies have examined the development of reading habits and reading skills as well as their relation over a longer period of time (Philipp, 2011). Stanovich, West and Harrison (1995) compared two small cohorts of college students ($N = 33$) and older adults ($N = 49$) to examine the role that reading habits (in sense of an index including information about the amount of reading or the extent to which specific reading activities are considered enjoyable) have on the growth and maintenance of knowledge across the lifespan. Correlational analyses showed a positive correlation between reading habits and vocabulary in college students. However, in older adulthood, no such correlation was found. In a recent study, Gebrande (2016), using data from the PIAAC (Programme for the International Assessment of Adult Competencies) study, examined women between the ages of 66 and 80 ($N = 626$) and showed that reading comprehension was correlated .37 with amount of reading. Gebrande (2016) also showed that even when controlling for educational background and age, women's reading comprehension still significantly predicted ($\beta = 0.21$) amount of reading.

Mol and Bus (2011) more extensively examined the relation between print exposure and components of reading skills from infancy to early adulthood in a meta-analysis of 99 studies ($N = 7{,}669$). Print exposure was measured by author-recognition and title-recognition tests and is understood as a proxy for the amount of reading that individuals engage in. In line with the aforementioned theoretical expectations, the authors showed that across all age groups, the correlations between print exposure and oral language increased with age. Correlations of print exposure with reading comprehension, technical reading and spelling skills remained stable. However, in their meta-analysis, Mol and Bus (2011) also stated that the correlations of print exposure with reading comprehension, technical reading and spelling skills showed increases when they took into account only the subset of primary and middle school children. Although meta-analyses are a powerful tool for summarising current research findings, there are certain restrictions that should be kept in mind. One major restriction is that in this meta-analysis, the different studies used different measures of reading comprehension. Also, print exposure is only a proxy and thus provided no information about the amount of time people spent reading. Furthermore, a variety of samples and sample sizes were included in the meta-analysis, and we do not

know how generalisable these samples were. Moreover, Mol and Bus (2011) did not consider (older) adults, indicating the need for primary studies to examine larger and preferably more representative samples.

However, an examination of adults' reading habits entails the necessity to take work-related or occupation-related reading into account (Diehl & Mikulecky, 1980; Kirsch & Guthrie, 1984; Smith, 2000) because adults spend most of their daily time at work and therefore have little leisure time left.

The role of occupation-related reading in adulthood

Adults read a lot on the job and for their jobs (Rammstedt, 2013) and sometimes spend more time reading at work than in their leisure time (Diehl & Mikulecky, 1980). Hence, as job-related reading seems to become more and more important in late adolescence and adulthood, it is necessary to take into consideration work-related reading and its role in adults' reading comprehension. A person never learns or reads in just one context (e.g., leisure time or work) while working with only one type of text (Moje, Dillon, & O'Brien, 2000). Instead, people tend to learn and develop differently in accordance with different contexts. Cross-sectional results from the PIAAC study have shown a positive correlation between reading in and for the job and adults' reading skills (Rammstedt, 2013). This is the only research that we know of that has examined the relation between occupation-related reading and reading comprehension. Nevertheless, there are other studies that have at least described the nature of adult reading practices for work. Kirsch and Guthrie (1984) examined a sample of 99 adults across various occupational categories and found that across all participants, people read more per day at work (127 min) than in their leisure time (80 min) on average. On the other hand, a diary study on reading by Smith (2000) showed that half of adults' total reading time occurred at home, one third took place at work, and the rest was done in the community (e.g., library, train, or airplane). Taken together, research that aims to examine the relation between reading habits and reading skills in adulthood should not neglect adults' occupation-related reading and its role in reading skill development.

Research questions

The present study pursued the following three research questions. First, is there a positive relation between time spent reading and reading comprehension skills across different age groups? On the basis of previous results (e.g., Anderson et al., 1988; Greaney & Hegarty, 1987; Guthrie et al., 1999; Mol & Bus, 2011; Pfost et al., 2010, 2013), we hypothesised that we would find a positive relation between time spent reading and reading comprehension skills in school student, college student and adult age groups.

Second, is there an increase in this correlation with age? According to the Matthew effect model in reading (Pfost et al., 2014; Stanovich, 1986; Walberg & Tsai, 1983), on the basis of a self-reinforcing mechanism between time spent reading and reading comprehension skills (the 'virtuous circle of reading' or the 'vicious circle of nonreading'), we expected a twofold fan-spread effect, which should result in a clearer differentiation between people on these variables, to occur. Ultimately, this differentiation should lead to an increase in the correlation between time spent reading and reading comprehension

skills (Mol & Bus, 2011). Therefore, we hypothesised that we would find a stronger correlation between time spent reading and reading comprehension skills in older adults in comparison with younger adults and school students. As the development of reading comprehension skills itself has been found to slow down as school students grow older, probably even reaching a stable reading competence level in later adolescence (Francis et al., 1996; Hill et al., 2008), we expected only minor changes in correlations within adults.

Third, is there a positive relation between occupational reading and reading comprehension skills? In accordance with results from Rammstedt (2013), whose study showed that adults who read frequently during work have higher reading skills than those who are less engaged in work-related reading, we further explored the role that reading in and for an occupational context has on adults' reading comprehension skills in comparison with their leisure-time reading. Therefore, we hypothesised that taking occupational reading in adulthood into account would explain additional variance in reading comprehension.

Method

Design and participants

The main goal of NEPS is to acquire longitudinal panel data on the development of competencies, educational processes and educational choices (Aßmann et al., 2011). NEPS aspires to draw population representative samples, which includes six starting cohorts (SCs; ranging from infants to adults). School students attending schools for children with learning difficulties were not included in our analyses. With regard to the fifth-grade cohort (SC3), our sample comprised $N = 4{,}354$ school students (48.8% were female). The average age was $M = 10.50$ ($SD = 0.62$) years. The cohort of ninth graders (SC4) was composed of a sample of $N = 10{,}983$ (51.0% were female) school students. The average age was $M = 14.67$ ($SD = 0.69$) years. The cohort of college students (SC5) comprised a sample of $N = 5{,}429$ (55.7% female) individuals. The average age was $M = 24.77$ ($SD = 2.82$) years. Finally, the adult cohort (SC6) contained a sample of $N = 8{,}029$ (50.20% were female) individuals. The average age was $M = 50.74$ ($SD = 10.91$) years. Table S1 provides a brief overview of the measurement points in NEPS for a better understanding of the NEPS data.

Measures

Time spent reading in the fifth-grade and ninth-grade cohorts. Time spent reading was measured with an overall evaluation of school students' reading time ('About how much time do you usually spend reading outside of school?') because this measure has been shown to be a valid and reliable measure of time spent reading for older as well as for younger people within NEPS (Locher & Pfost, 2019). School students were asked to provide two estimates: one concerning extracurricular reading 'on a normal nonschool day' and one concerning extracurricular reading 'on a normal school day'. School students were asked to consider all reading opportunities (i.e., not just printed books and magazines but also emails and websites). Therefore, a 5-point Likert scale was used (1 = *never or almost never* to 5 = *more than 2 h a day*). Both estimates were used in our analyses.

Time spent reading in the college student and adult cohorts. Time spent reading was measured in the same manner as in the fifth-grade and ninth-grade cohorts but was adapted to the age/living conditions of the participants ('About how much time do you usually spend reading outside your job/studies?' plus 'About how much time do you usually spend reading in and for your job/studies?'). Similar to the fifth-grade and ninth-grade cohorts, participants were asked to consider all reading opportunities and to specify the average duration of reading in minutes per day. For our analyses, we recoded responses to these open-ended questions in a manner that was comparable to the response scales used in the fifth-grade and ninth-grade cohorts.

Reading comprehension. In the NEPS, reading comprehension was defined with regard to the reading literacy concept, which highlights functional facets of reading in occupational, educational and informal settings (Gehrer & Artelt, 2013). Across all starting cohorts and age groups, the same literacy concept was applied as a starting point for the development of the NEPS reading tests. In doing so, reading comprehension was measured coherently across the lifespan while also being adapted to the abilities of the particular age group being tested. Each test was composed of five texts (informational texts, commentaries or argumentative texts, literary texts, instructional texts and advertising texts) with four to eight items per text type (Gehrer & Artelt, 2013; Pohl, Haberkorn, Hardt, & Wiegand, 2012). The reading comprehension data were scaled on the basis of the item response theory (Pohl & Carstensen, 2012) model. For our analyses, we used weighted likelihood estimation scores. The reliability of the comprehension tests, with slight variations between the cohorts, was found to be good in all cohorts (weighted likelihood estimation reliability = .590–.767; Haberkorn, Pohl, Hardt, & Wiegand, 2012; Hardt, Pohl, Haberkorn, & Wiegand, 2013; Pohl & Carstensen, 2012; Pohl, Haberkorn, & Hardt, 2014). The quality of the items, and therefore of the test, has been checked in various analyses (e.g., differential item functioning) for each cohort. Furthermore, the unidimensionality of the reading comprehension construct, which includes the five different text types, has also been checked (Haberkorn et al., 2012; Hardt et al., 2013; Pohl et al., 2014; Pohl & Carstensen, 2012).

Educational background. The German secondary school system is characterised by the explicit tracking of school students into different types of schools (LeTendre, Hofer, & Shimizu, 2003). Despite regional differences in Germany, explicit tracking regularly takes place after the transition from primary to secondary school (generally from Grade 4 to Grade 5). With regard to our analyses, we differentiated academic track schools, which allow school students to attend a university after 12–13 years of education, and nonacademic track schools, which usually prepare school students for vocational training. Decisions such as whether school students will attend academic or nonacademic schools are based primarily on school students' performance. However, variables such as school students' social background are also taken into account (e.g., Maaz & Nagy, 2010). In the school student cohorts, the students were asked about the type of school they were currently attending. In the adult cohort, we asked whether the person had attended an academic track school or not. In the college cohort, educational background was not considered in our analyses because the sample in this cohort was required to have attended an academic school or had to have at least an equivalent type of university entrance qualification to be accepted into college. Therefore, we could implicitly assume that all college students had attended the academic track.

Analysis strategy

Regression analyses. Analyses were computed in SPSS and Mplus 7 (Muthén & Muthén, 1998). First, we computed descriptive statistics and zero-order correlations. We therefore report confidence intervals (CIs) as well. For the confidence intervals, we used a bootstrapping confidence interval method because it does not require additional assumptions about the distribution of the sample. We conducted 2,000 bootstrapping simulations (Gediga, 2010). Then, to explore the relation between time spent reading and reading comprehension, we regressed the reading comprehension measures on time spent reading within every starting cohort. As the age range in the adult cohort was quite high (range: 25 to 70 years, *SD* = 10.91), we divided this cohort into three age groups: adults younger than 35 years, adults between the ages of 35 and 55 years and adults older than 55 years. Prior research has shown significant differences between school-aged boys and girls related to their reading habits and skills (Bos, Schwippert & Stubbe, 2007; Martin & Mullis, 2013; OECD, 2010, 2016a). Furthermore, academic competencies, including reading comprehension, have shown strong relations to people's individual educational backgrounds (OECD, 2016b; Weis et al., 2016). Therefore, in order to avoid overestimating the relation between reading comprehension and time spent reading, we ran a model with gender and educational background as covariates in the first step.

In the second step, the reading time measures were added to the regression model that already contained the covariates. ΔR^2 was reported to depict the increase in the variance explained by the reading time variables.

Because of the repeated administration of the reading comprehension measure in the fifth-grade (Grades 5 and 7) and ninth-grade (Grade 9 and 12) cohorts, we further tested for whether time spent reading affected the development of interindividual differences in reading comprehension. Therefore, we regressed reading comprehension (Time 2) on both time spent reading (Time 1) and reading comprehension (Time 1). We compared the findings across the different cohorts and age groups. The longitudinal model is shown in Figure 1. We used cluster robust standard errors in both school student cohorts to handle the nested data (TYPE = COMPLEX). We used an MLR estimator in all models.

Missing values. The initial data set contained cases with missing data on all variables of interest. We excluded these cases in advance. In the final data sets, the frequency of missing values varied from 0% to 34.6%. The highest rate of missing data was observed for reading comprehension in the adult cohort because just two thirds of the participants took the reading tests in addition to the surveys. For the correlation analyses, we used listwise

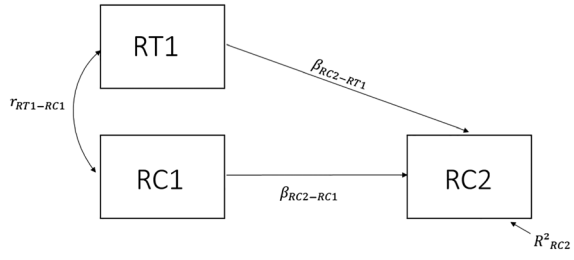

Figure 1. Regression model of reading comprehension regressed on time spent reading. *Note:* Represented in the figure are standardised regression coefficients β, the estimated correlation *r* and the unexplained variance R^2. RC, reading comprehension; RT, reading time.

deletion. In the regression analyses, missing data were treated with full information maximum likelihood estimation because full information maximum likelihood has been shown to be an effective approach in the treatment of missing data (Lüdtke, Robitzsch, Trautwein, & Köller, 2007). However, for descriptive and exploratory analyses, listwise deletion also seems to be acceptable (Lüdtke et al., 2007).

Results

Table 1 shows the means, standard deviations and the 95% CIs for the variables of interest in the different starting cohorts. In Grades 5 and 9, we had two measures of extracurricular reading: on a normal school day and on weekends/holidays. In Grades 5 and 9, school students, on average, indicated reading between 30 and 60 min a day. Grade 9 school students indicated reading slightly more than Grade 5 school students, but the difference was only marginal when considered in absolute terms. However, the 95% CIs did not overlap. Therefore, the difference could be considered significant.

College students were asked to indicate their extracurricular reading time and the amount of time they spent reading for their studies. On average, they indicated reading about 30 to 60 min ($M = 2.78$) per day in their leisure time. Therefore, in comparison with our secondary school students, college students indicated reading less in their spare time. However, these differences should not be overinterpreted due to the different original response scales. Furthermore, college students indicated spending substantially more time reading for their studies ($M = 4.00$, which is equivalent to about 1 to 2 h of reading a day). Finally, adults' volume of leisure-time reading exceeded that of college students' ($M = 3.06$). The 95% CIs did not overlap. Adults also indicated an average of about 1 to 2 h of reading per day for work. Therefore, adults' work-related reading exceeded their leisure-time reading (the 95% CIs did not overlap).

Tables 2 and 3 show the intercorrelations between the different reading-time variables (below the diagonal) and the corresponding CIs (above the diagonal) separately for each starting cohort. An inspection of the measurements from the fifth-grade cohort (Grades 5 to 7; Table 2) as well as the ninth-grade cohort (Grades 9 to 12; Table 2) revealed strong correlations between extracurricular reading on weekends/holidays and reading on school days ($r = .65$ and .78). Relations between school students' leisure-time reading and school students' reading comprehension varied from .21 to .30 (Grades 5 and 7) and .23 and .29 (Grades 9 and 12). A closer inspection of Table 2 revealed that within both cohorts, out-of-school reading on school days had lower correlations with reading comprehension than out-of-school reading on weekends/holidays (the 95% CIs did not overlap).

An inspection of the college student cohort and adult cohort measurements (both in Table 3) revealed very small correlations between occupation-related reading and leisure-time reading ($r = .16$ and .10). Moreover, Table 3 shows that reading comprehension had small negative correlations with study-related reading and leisure-time reading ($r = -.05$). A closer look at the adult cohort in Table 3 reveals that work-related reading was more strongly correlated with reading comprehension ($r = .28$) than leisure-time reading ($r = .10$). As can be seen, the 95% CIs did not overlap. Table 3 further reveals that the correlation between leisure-time reading and reading comprehension in the adult cohort was stronger than in the college student cohort (the 95% CIs did not overlap).

Table 1. Means and standard deviations of reading comprehension and time spent reading in the different study cohort samples

	Grade 5 (N = 3,319)			Grade 9 (N = 4,645)			College (N = 4,798)			Adulthood (4,194)		
	M	(*SD*)	95% CI	*M*	(*SD*)	95% CI	*M*	(*SD*)	95% CI	*M*	(*SD*)	95% CI
Reading comprehension[a]	0.20	(1.33)	[0.16, 0.24]	0.57	(1.15)	[0.52, 0.59]	0.06	(0.88)	[0.04, 0.09]	0.08	(1.31)	[0.04, 0.12]
Reading time												
Weekend/holiday	3.06	(1.36)	[3.01, 3.11]	3.37	(1.27)	[3.33, 3.41]						
School day	3.00	(1.19)	[2.96, 3.04]	3.13	(1.33)	[3.09, 3.16]						
All days							2.78	(0.98)	[2.76, 2.81]	3.06	(0.95)	[3.03, 3.09]
Reading for study							4.00	(0.98)	[3.97, 4.03]			
Reading for work										3.59	(1.39)	[3.55, 3.63]

5-point Likert scale for reading volume variables (1 = *I do not read outside school*; 2 = *30 min or less a day*; 3 = *More than 30 min to less than 60 min a day*; 4 = *1 to 2 h a day*; 5 = *More than 2 h a day*). Means, SD and CI of all variables are estimated in one bootstrapping model. Missing data was treated by listwise deletion.
[a]Weighted likelihood estimator.

Table 2. Pearson correlations and 95% confidence intervals

	a.	b.	c.	d.
Five graders cohort				
a. School day	1	[0.63, 0.67]	[0.18, 0.24]	[0.16, 0.23]
b. Weekend/holiday	0.65**	1	[0.27, 0.33]	[0.27, 0.33]
c. Reading comprehension (Grade 5)	0.21**	0.30**	1	[0.58, 0.62]
d. Reading comprehension (Grade 7)	0.19**	0.30**	0.60**	1
Ninth graders Cohort				
a. School day	1	[0.77, 0.80]	[0.20, 0.25]	[0.19, 0.25]
b. Weekend/holiday	0.78**	1	[0.27, 0.32]	[0.26, 0.32]
c. Reading comprehension (Grade 9)	0.23**	0.29**	1	[0.57, 0.61]
d. Reading comprehension (Grade 12)	0.22**	0.29**	0.59**	1

Grade 5: $N = 3{,}319$; Grade 9: $N = 4{,}645$. Pearson correlations below the diagonal and 95% CIs above the diagonal. Means and CI of all variables are estimated in one bootstrapping model. Missing data was treated by listwise deletion.
*$p < .05$.
**$p < .01$.

Table 3. Pearson correlations and 95% confidence intervals

	a.	b.	c.
College student cohort			
a. Study-related	1	[0.13, 0.18]	[−0.08, −0.03]
b. Leisure time	0.16**	1	[−0.08, −0.02]
c. Reading comprehension	−0.05**	−.05**	1
Adult cohort			
a. Work-related	1	[0.07, 0.13]	[0.25, 0.31]
b. Leisure time	0.10**	1	[0.09, 0.15]
c. Reading comprehension	0.28**	0.12**	1

College: $N = 4{,}798$; Adult: $N = 4{,}194$. Pearson correlations below the diagonal and 95% CIs above the diagonal. Means and CI of all variables are estimated in one bootstrapping model. Missing data was treated by listwise deletion.
*$p < .05$.
**$p < .01$.

Regression analyses

Table 4 presents results for the regression model, which predicted reading comprehension from time spent reading while controlling for educational background and gender in different starting cohorts/age groups. As mentioned, the adult cohort was split into three groups (age < 35; $35 \leq$ age ≤ 55; age > 55). In addition, we report ΔR^2 for the comparison of the

Table 4. Regression of reading comprehension on time spent reading in different study cohorts (cross-sectional results)

	Grade 5		Grade 9		College		Age < 35		35 < Age < 55		Age > 55	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
Intercept	−0.90**	(0.06)	−0.76**	(0.03)	0.33**	(0.08)	−0.80**	(0.19)	−0.98**	(0.09)	−1.40**	(0.11)
Gender	0.02	(0.02)	0.01	(0.01)	0.02	(0.02)	0.06	(0.04)	0.03	(0.02)	0.07**	(0.02)
Academic track	0.35**	(0.02)	0.39**	(0.01)	—	—	0.36**	(0.04)	0.34**	(0.02)	0.28**	(0.02)
Extracurricular reading:												
Weekend/holiday	0.22**	(0.02)	0.23**	(0.02)								
School day	0.03	(0.02)	0.02	(0.02)								
All days					−0.04**	(0.02)	0.07	(0.04)	0.07**	(0.02)	0.06**	(0.02)
Study-related reading:												
All days					−0.05*	(0.02)						
Work-related reading:												
All days							0.13**	(0.05)	0.23**	(0.02)	0.21**	(0.03)
R^2		.221**		.256**		.005*		.186**		.212**		.156**
ΔR^2		.049**		.053**		.005**		.026**		.060**		.049**
N	4,354		10,983		5,429		924		4,096		3,009	
Cluster	445		920		—		—		—		—	

Reported results are standardised. Nested data in Grades 5 and 9 were considered by using cluster robust standard errors. Missing data were treated by using full information maximum likelihood estimation.
*$p < .05$.
**$p < .01$.

first step of the regression model, which contained just the covariates, and the second step of the model, which included all variables that referred to time spent reading. In the fifth-grade cohort, leisure-time reading on weekends/holidays was a statistically significant predictor ($\beta = 0.22$, $p < .01$) of reading comprehension (Table 4, Column 1). By contrast, leisure-time reading on normal school days was not a significant predictor ($\beta = 0.03$, *ns*) of reading comprehension. Gender did not predict reading comprehension. However, attending an academic track school significantly predicted school students' reading comprehension. In the ninth-grade cohort, similar results were found. Reading on weekends/holidays ($\beta = 0.23$, $p < .01$) and extracurricular reading on school days ($\beta = 0.02$, *ns*) predicted reading comprehension with a magnitude that was comparable to the magnitude found in Grade 5.

In college students (Column 3), leisure-time reading was a negative, although very weak, significant predictor ($\beta = -0.04$, $p < .05$) of reading comprehension. We found relations of a similar magnitude for study-related reading ($\beta = -0.05$, $p < .01$). Finally, for adults under the age of 35, leisure-time reading was not a significant predictor of reading comprehension. In both of the other age groups, leisure-time reading was a weak, positive predictor of reading comprehension ($35 \leq \text{age} \leq 55$: $\beta = 0.07$, $p < .01$; age > 55: $\beta = 0.06$, $p < .01$). The relation between work-related reading and reading comprehension was found to be positive and significant for all age groups (age < 35: $\beta = 0.13$, $p < .01$; $35 \leq \text{age} \leq 55$: $\beta = 0.23$, $p < .01$; age > 55: $\beta = 0.21$, $p < .01$). Gender was again not related to reading comprehension (except age < 55), whereas educational background substantially predicted reading comprehension. In order to examine whether the (re) categorisation of time spent reading led to systematically biased results, we ran further regression analyses of college students and adults against the original open-ended reading-time response scale. Results showed no substantial differences in the direction or magnitude of the effects, changing the interpretation of our findings (for further information, see Table S2).

Regarding ΔR^2, which reflects the combined effect of all reading-time variables beyond the covariates gender and educational background, the reading-time variables (which included everyday reading, reading on schooldays, reading on weekends/holidays, reading for studies and occupational reading) explained 4.7% to 5.5% of the variance in school students' reading comprehension in Grades 5 and 9 ($\Delta R^2 = .047$–$.055$). In the college cohort ($\Delta R^2 = .005$) and the adults under 35 ($\Delta R^2 = .026$), time spent reading hardly explained any variance in reading comprehension. On the other hand, the reading variables explained 6.0% of the variance in reading comprehension in the 35 to 55 year olds ($\Delta R^2 = .060$) and 4.9% in those older than 55 ($\Delta R^2 = .049$).

Time spent reading and reading comprehension development

Because of the availability of longitudinal data in the fifth-grade and ninth-grade cohorts, we further examined individual differences in the development of reading comprehension in relation to school students' extracurricular reading time (see Figure 1). We again compared the two school student cohorts, but this time, instead of examining cross-sectional correlations, we predicted individual differences in reading comprehension development on the basis of school students' extracurricular reading time between Grades 5 and 7 and between Grades 9 and 12. In both cohorts, the rank-order stability was substantial (RC2 on RC1; $\beta \sim 0.60$, Table 5). Moreover, the results showed that the cross-lagged paths

were nearly stable (RC2 on RV1; reading on weekends/holidays: β = 0.13 in both cohorts; reading on school days: β = 0.07 and 0.09) between the cohorts. This demonstrates that time spent reading had a similar effect on reading comprehension in both Grades 5 and 9. In both cohorts, individual differences in the development of reading comprehension were predicted by time spent reading, meaning that school students who indicated that they spent more time engaged in extracurricular reading showed better development in their reading comprehension skills. When comparing the models containing the reading-time variables with the basic model (RC2 on RC1), which only contains the prediction of reading comprehension at Time 1 by reading comprehension at Time 2, the reading-time variables explained 1% to 4% of the variance found in school students' reading comprehension in Grades 5 and 9 (ΔR^2 = .007–.039) over and above previous reading comprehension.

Discussion

Our main interest in conducting this study was to describe and compare relations between time spent reading and reading comprehension skills across four cohorts in order to find some indication of whether age in any way moderates this relation. On the basis of previous studies, we expected to find positive correlations between leisure-time reading and reading comprehension. Second, we expected the correlations between leisure-time reading and reading comprehension to increase with age, reaching a stable level in young adulthood. Finally, we expected to find positive correlations between work-related reading and reading comprehension in adulthood. Not all our hypotheses were supported by our

Table 5. Reading comprehension regressed on time spent reading

		Grade 5		Grade 9	
		β	*SE*	β	*SE*
Reading on weekend/holiday					
Stability of reading comprehension	$\beta_{RC2\ -\ RC1}$	0.58**	0.01	0.57**	0.01
Correlations	$r_{RT1\ -\ RC1}$	0.31**	0.02	0.33**	0.01
Cross-lagged path	$\beta_{RC2\ -\ RV1}$	0.13**	0.01	0.13**	0.01
Residual variance	$R2_{RC2}$	0.60**	0.02	0.62**	0.01
N		4,353		10,969	
Reading on school days					
Stability of reading comprehension	$\beta_{RC2\ -\ RC1}$	0.61**	0.01	0.58**	0.01
Correlations	$r_{RT1\ -\ RC1}$	0.22**	0.02	0.25**	0.01
Cross-lagged path	$\beta_{RC2\ -\ RV1}$	0.07**	0.01	0.09**	0.01
Residual variance	$R2_{RC2}$	0.61**	0.02	0.63**	0.01
N		4,354		10,973	

Reported results are standardised. Nested data in Grades 5 and 9 were considered by using cluster robust standard errors. Residual variance of basic model (RC2 on RC1) was R^2 = .617 in Grade 5 and R^2 = .655 in Grade 9. Missing data were treated by using full information maximum likelihood estimation. RC, reading comprehension; RT, reading time.
*$p < .05$.
**$p < .01$.

empirical data. In the following section, we will discuss our findings and their importance with respect to our hypotheses.

In all age groups, apart from the college cohort, time spent reading was positively correlated with reading comprehension, which provides sound support for our first hypothesis, which predicted a positive association between the two constructs across the lifespan in all age groups. This finding is well-aligned with the results from Mol and Bus (2011), who took into account a large age range that spanned from childhood to adolescence, as well as with results from studies focusing on younger school students such as Guthrie et al. (1999) or Pfost et al. (2013). With respect to our second hypothesis, we predicted that the relation would increase with age, probably reaching a stable level in adulthood. Our results did not support this hypothesis. Our results regarding the cohort of school students did not show an increase or a decrease in the correlation between time spent reading and reading comprehension between the fifth-grade and ninth-grade cohorts but instead showed nearly stable effects. The similar cross-lagged paths showed that leisure-time reading had a small positive effect on reading comprehension in both cohorts. However, the cross-lagged paths from Grades 5 to 7 and from Grades 9 to 12 had the same magnitude. One possible explanation for the similar relation between time spent reading and reading comprehension in the two cohorts is that the stable level of the correlation between time spent reading and reading comprehension, which we expected to find in later adolescence/adulthood because of a stable competence level (Francis et al., 1996), had already been reached in secondary school, or at least the relation was no longer increasing substantially at this point.

In addition to the longitudinal results, the cross-sectional relations in college students showed that readers with low reading comprehension levels spent more time reading than readers with a high reading comprehension level. However, the size of this effect was quite low. In our opinion, there might be two explanations for this contradictory finding. First, because of their lower reading comprehension levels, poor readers need more time to read the same amount of text, resulting in a negative association between indicators of reading time and reading comprehension. Second, different from the other cohorts in this study, the college student cohort was not a representative sample of young adults because this cohort was composed of only college students. College students are highly qualified (readers), especially in the German education system where individuals are only allowed to attend college if they have already completed secondary school at the academic track. Consequently, variance restrictions, especially those regarding the reading comprehension measures, were present and might have affected this finding.

For the adult cohorts, our findings showed a reduced correlation between time spent reading in leisure time and reading comprehension in comparison with the student cohorts. These results contradict the predictions we made on the basis of our theoretical model – the Matthew effect in reading (Pfost et al., 2014; Stanovich, 1986). Under the assumption that reading comprehension development declines as individuals grow older and stabilises in adulthood (Francis et al., 1996; Hill et al., 2008), while further assuming only a minor change in time spent reading for enjoyment between adolescents and adults, we might have expected the relation between reading comprehension and time spent reading to remain constant rather than to decrease over time.

There are three explanations that might account for the decrease we found in the relation between leisure time reading and reading comprehension with age. The first explanation concerns the method we used to measure time spent reading as we exclusively focused on quantity of reading. However, in addition to the quantitative aspect, it is plausible that

adults read other types of texts and for other purposes in comparison with children and adolescents. Therefore, the lower correlations might reflect qualitative changes in reading habits even if time spent reading does not vary substantially with age. Second, we referred to the Matthew effect model in reading (Pfost et al., 2014; Stanovich, 1986) in order to derive and explain our theoretical assumptions regarding an increase in the correlation between reading and reading comprehension across the lifespan. However, after analysing our data, we might restrict the validity of the Matthew effect in reading (upward or downwards spiral of causality through a reciprocal relation between time spent reading and reading skills) to school students and young adolescents. In adulthood, there might be other restrictions (e.g., job or family commitments) that influence the amount of leisure time an adult can take for themselves, which in turn impacts their reading habits. Fend, Berger and Grob (2004), for example, showed that a high work load (weekly working hours) negatively predicted the amount of time adults spent reading. This means that, because of restrictions (e.g., time), any intrinsic reading motivation that exists cannot be transformed into an equivalent amount of reading time. In other words, with regard to general models of cumulative advantage and positive feedback loops (DiPrete & Eirich, 2006; Rigney, 2010), we might say that external restrictions on opportunity structures (e.g., job or family commitments) restrict self-selection processes (e.g., leisure-time reading) and consequently undermine the emergence of further Matthew effects in adulthood. Furthermore, current research using behavioural–genetic approaches has cast doubt on the idea that the amount of reading contributes to individual differences in reading comprehension as children become older (van Bergen et al., 2018).

Finally, the decrease in the correlation between leisure time reading and reading comprehension with age might be linked to our third research question on the role of adults' occupation-related reading. The comparably large volume of work-related reading in adults has shown that the reading people do for their jobs has a great deal of relevance. These results correspond with findings by Kirsch and Guthrie (1984), who also found that a large amount of the reading that the adults in their study did was work-related. Our results also showed that the relevance of work-related reading tends to increase with age because adults spend more time reading in and for their jobs than during their leisure time. The weak correlation found between leisure-time reading and occupational reading time indicates that reading in the context of leisure and reading in the occupational context are worthy of being considered separately because a person's reading habits appear to vary between the two contexts. The correlation between occupation-related reading and reading comprehension was substantially higher than the correlation for leisure-time reading. These findings support our third (and last) hypothesis, which proposed that occupational reading is also related to reading comprehension. However, the causal direction is still an open question; we cannot say whether good readers choose jobs for which they need to do a lot of reading or whether these individuals are good readers as a result of the time they spend reading in and for their jobs (see also Rammstedt, 2013). To answer this question, additional longitudinal data are needed.

Limitations of the study

In this study, there were similar conditions across all age groups with regard to time frames, administration, sampling procedure, and the dependent variable of reading comprehension. However, one limitation of our study was that our measures of reading time

changed slightly between the school student cohort and the college and adult cohorts because we had to adapt the measures appropriately with respect to the ages and life conditions of the participants. For the younger participants who were placed in the school student cohort, a closed-response format was used, whereas those placed in the college and adult cohorts were provided an open-response format to obtain the greatest amount of information possible. We further conducted a set of additional regression analyses, and the results did not show any substantial differences in the results between the regression using the categories and the regression using the open-ended response values in adulthood. However, the Likert scales probably gave the school students fixed frames of reference. These given time frames might have influenced participants' estimations of how much reading they do. Second, all our reading-time data were based on self-reported rating scales. Therefore, we cannot say whether aspects of social acceptance or memory effects might also have biased the participants' reports. To handle this issue, it might be helpful to include teacher or parent ratings or to additionally use measures such as the title recognition test (e.g., Cipielewski & Stanovich, 1992) or reading diaries. Third, prior research has shown that reducing the measurement of reading time to just an overall quantitative evaluation is not always the best way operationalise it. Especially because participants were asked to not only include the printed books and magazines they read but also any emails and websites. We know from recent research that differential effects can be found between the reading of each of these types of texts and reading skills (e.g., McGeown, Duncan, Griffiths, & Stothard, 2015; McGeown, Osborne, Warhurst, Norgate, & Duncan, 2016; Pfost et al., 2013). Unfortunately, we had no way of using an evaluation regarding different genres as an indicator of reading time because findings by Locher and Pfost (2019) revealed some issues with regard to the validity and reliability of these measures in the NEPS framework. However, future research might want to take into account differentiated evaluations related to different types of texts in order to consider qualitative aspects of reading. Moreover, it would be desirable for future research to have information on school students' reading activities during their school lessons.

Conclusion and implications for further research

The present study is among the first to take a closer look at the course and the relations of extracurricular and occupational reading facets as well as reading comprehension across a long time span ranging from early adolescence to late adulthood in one study. Results revealed new insights into this topic and raised new questions that can be examined in future research. First, we showed that the relation between time spent reading and reading comprehension between Grades 5 and 9 is nearly stable. Second, the relation between time spent reading in leisure time and reading comprehension in adulthood decreases when comparing adolescents and adults. Finally, work-related reading appears to become more important in adulthood, even when educational status and gender are controlled for.

The ability to read is essential for participation in cultural, political and economic life, and the activity of reading itself is seen as one of the most influential factors of such reading abilities (Mol & Bus, 2011). However, evidence for the relation between time spent reading or amount of reading and reading skills (e.g., reading comprehension) has been limited to childhood and adolescence. Still today, little is known about

adults' reading habits as well as how these habits are related to adult variables (e.g., reading comprehensions or reading motivation), and thus, we addressed this gap in our study. Our findings benefitted from a large and representative sample of about 28,000 participants as well as the use of high-quality competence measures that allowed for a meaningful comparison of the findings across a wide age range. In sum, our results did not confirm the theoretical assumptions derived by the Matthew effect model because we found a decrease in the relation between reading comprehension and time spent reading in leisure time with age. Therefore, we need to question whether results based on school students (e.g., Anderson et al., 1988; Greaney & Hegarty, 1987; Pfost et al., 2010, 2013) can really be generalised to all age groups or whether they are valid only for the younger members of the population. Furthermore, the great importance of occupation-related reading in adulthood again underlines our first statement: Reading is a process that changes across the lifespan.

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