



Wicht, Alexandra; Durda, Tabea; Krejcik, Luise; Artelt, Cordula; Grotlüschen, Anke; Rammstedt, Beatrice; Lechner, Clemens

Low literacy is not set in stone. Longitudinal evidence on the development of low literacy during adulthood

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Alphabetisierung und Grundbildung von Erwachsenen



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Alphabetisierung und Grundbildung von Erwachsenen

Herausgegeben von Anke Grotlüschen



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Low Literacy is not Set in Stone

Longitudinal Evidence on the Development of Low Literacy During Adulthood¹

Abstract: In most industrialized societies, around 10-15% of adults are only able to read at basic levels, a phenomenon commonly termed 'low literacy'. This study addresses two questions about the development of low literacy during adulthood: (1) How stable is low literacy in adults, that is, what share of adults experiences ascents from, or descents into, low literacy? (2) What risk and protective factors predict such ascents and descents, as well as changes in literacy within the subgroup of low-literate adults? We use largescale data from the German National Educational Panel Study (NEPS), which provides repeated measures of adults' literacy spanning up to six years. We identified low-literate adults based on a cut score derived using the bookmark method. We found that ascents from low literacy to higher literacy were more prevalent than descents from higher literacy to low literacy. Almost a third of low-literate adults ascended from low literacy to higher literacy after four to six years. Reading practices emerged as the most important protective factor against descents from higher literacy and predicted gains in literacy within the group of low-literate adults. Overall, our study suggests that low literacy is not an immutable condition in adulthood, but has the potential to change over an individual's lifetime, meaning that gains in literacy over time are indeed possible among low-literate adults.

Keywords: Low Literacy, Literacy Development, Large-Scale Assessment, Adults, National Educational Panel Study

1. Introduction

In 2018, more than 6.2 million German-speaking adults in Germany were deemed as having a low level of proficiency in reading and writing. These 'low-literate' adults can read and write letters, words, and short sentences, but have difficulties at (short) text level. Although the share of low-literate adults is 2.4 percentage points lower than in 2010, the proportion of low-literate adults still amounts to 12.1 percent of the German-

¹ This work was supported by the German Federal Ministry of Education and Research (BMBF) funding the project "Risk and protective factors for the development of low literacy and numeracy among German adults" (Grant No. W143700A). The analyses are based on data from the National Educational Panel Study (NEPS): Starting Cohort 6 ("Adults"), DOI:10.5157/NEPS:SC6:9.0.1. From 2008 to 2013, NEPS data were collected as part of the Framework Program for the Promotion of Empirical Educational Research funded by the BMBF. As of 2014, NEPS is carried out by the Leibniz Institute for Educational Trajectories (LIfBi) at the University of Bamberg in cooperation with a nationwide network.

speaking population in Germany (Grotlüschen, Buddeberg, Dutz, Heilmann & Stammer, 2019). Low literacy in adulthood often has considerable social, occupational, and health consequences for individuals and bears the risk of social exclusion. At the same time, low literacy incurs high costs for societies as a whole, for example, as a result of welfare and social programs, or basic adult education programs (Egloff, Grosche, Hubertus & Rüsseler, 2011; Green, 2013; Grotlüschen, Mallows, Reder & Sabatini, 2016).

In order to implement targeted educational policies and pedagogical measures that tackle low literacy, it is essential to form a comprehensive understanding of how and why literacy evolves throughout a person's lifetime. Currently, there is a dearth of knowledge about the development of literacy during adulthood in general (but see the recent studies by Reder, Gauly & Lechner, 2020, and Wicht, Rammstedt & Lechner, 2020), particularly when it comes to low-literate adults. From a life-course perspective, the probability of skill gains among low-literate adults and the risk of skill losses among adults with initially functional literacy levels are shaped by formal, non-formal and informal learning environments and cognitive-related factors (Grotlüschen et al., 2019; Paccagnella, 2016). However, the few existing studies available from the field of adult education are almost exclusively cross-sectional (for reviews, see Desjardins & Warnke, 2012; Paccagnella, 2016) and/or cannot be easily compared to studies conducted within a German context. Thus, no conclusions can be derived from the available cross-sectional data in terms of how low literacy evolves in adulthood and what factors may drive potential changes.

The present study aims to close this gap. We draw on data from Starting Cohort 6 ("Adults") of the German National Education Panel Study (NEPS; Blossfeld & Roßbach, 2019) in which literacy was measured twice across a four to six-year interval. Building on a functional perspective on reading (Gehrer, Zimmermann, Artelt & Weinert, 2013; OECD, 2009), literacy measures focus on the competent handling of texts in various situations characteristic of everyday life. Based on these data, we seek to answer two guiding questions about the development of low literacy: First, how stable or malleable is low literacy over time? In other words, what share of adults experiences a change in their literacy proficiency – either in the form of descent from higher literacy into low literacy or ascent from low literacy to higher literacy?² Second, what risk and protective factors predict such ascents from, or descents into, low literacy – as well as changes over time in literacy within the subgroup of low-literate adults? With regard to potential risk and protective factors, we consider reading practices (e.g., reading quantity) and socio-demographic characteristics (e.g., formal education, employment) as indicators of the informal and formal learning environment. We also consider cognitive

² As we have defined only one threshold for the group of adults with low literacy in this study, we refer to individuals below the threshold as 'low-literate adults' and the group above the threshold as 'adults with higher literacy'. Both groups are complementary. By using the denomination 'higher literacy', we take into account that the large group of people with proficiencies above the defined threshold is itself heterogeneous and that further definitions of threshold values are possible.

abilities (e.g., perceptual speed, reasoning). These are factors that previous research has identified as critical contributors to literacy development (for a review, see Nienkemper & Grotlüschen, 2020).

2. Previous Theorizing and Research

2.1 Reading Practices as a Key Driver of Literacy Development

In adulthood, once most individuals have finished their general education, most learning takes place outside formal settings (Eaton, 2010; Livingstone, 2001). In line with constructivist learning theories (e.g., Lave & Wenger, 1991; Mezirow & Taylor, 2009), non-formal learning processes (uncertified structured learning, e.g., through further education) and informal learning processes (self-directed learning or possible inadvertent learning from experiences) are therefore thought to be responsible for the further development of proficiencies during adulthood. Dominant theories of literacy development, such as practice engagement theory (Reder, 2009b; Reder et al., 2020), also emphasize individuals' practices in everyday settings as a means of explaining literacy gains and losses.

These theoretical strands find support in the form of previous research demonstrating that adults' reading practices play a pivotal role in changes in literacy proficiency (Bynner & Parsons, 1998; Desjardins & Warnke, 2012; Grotlüschen et al., 2019; Wicht et al., 2020; Zeuner & Pabst, 2011). For example, the study "Use It or Lose It" demonstrates that literacy decreases within two years after a lack of engagement with reading practices in working contexts (Bynner & Parsons, 1998). Furthermore, findings from the Longitudinal Study of Adult Learning (LSAL) suggest that basic adult education programs are linked to increases in reading practices (e.g., filling out a form, creating shopping lists) in the short term. Reder (Reder, 2005, 2009b) speculates that literacy proficiencies might increase in the long run due to stabilized reading practices. Reder et al. (2020) recently found reading practice to be the strongest predictor of literacy gains over a period of three years by drawing upon multi-wave data for Germany from the Programme for the International Assessment of Adult Competencies (PIAAC) and longitudinal data from the national extension study (PIAAC-L).

2.2 Interrelations of Reading Practices and Stimulating Social Environments

Engaging in reading practices is strongly contingent upon stimulating social environments as well as daily needs and requirements which correlate with individuals' sociostructural characteristics (Barton & Hamilton, 1998; Gasteiger-Klicpera & Klicpera, 1994; Heath, 2012). In this sense, the term "reading practices" emphasizes reading as a behavior or a set of social practices that are inhibited or encouraged by social living conditions (Gray & Rogers, 1956; Smith, 2000). Reder and colleagues (Bynner & Parsons, 1998; Reder, 2010; Reder et al., 2020) have repeatedly shown that adults whose life circumstances demand more frequent engagement in reading practices are more likely to improve their proficiencies.

The workplace is arguably the most important context in which adults engage with reading practices to fulfill given tasks. For example, adults who work in unskilled or low-skilled positions are confronted with written material less often. Also, the material they do encounter is less demanding (Smith, 2000). Moreover, as the workplace is a crucial source of engagement with written content, non-employment is likely to reduce engagement with written material because non-employed people face no engagement requirement (Bynner & Parsons, 2006; Reder, 2009a). This, in turn, may hamper literacy development among the non-employed. Multiple cross-sectional studies demonstrate that the prevalence of low literacy is higher among non-unemployed compared to employed individuals (Durda, Gauly, Buddeberg, Lechner, & Artelt, 2020; Grotlüschen, Mallows, Reder & Sabatini, 2016; Grotlüschen et al., 2019). These studies include the German first and second "Level One Study" (LEO; Grotlüschen et al., 2019; Grotlüschen & Riekmann, 2012), the study "Working and Learning in a Changing World" (ALWA; Antoni et al., 2010), and the international comparative study "Programme for the International Assessment of Adult Competencies" (PIAAC; OECD, 2016; German national report, Rammstedt et al., 2013). These cross-sectional findings align with longitudinal findings in a subsample of the British Cohort Study (BCS) by Bynner and Parson (2006). The authors highlight employment-related factors such as labor market participation and receiving work-related training as essential predictors for descents into, or ascents from, low literacy proficiency levels (but see Gauly & Lechner, 2019).

The aforementioned cross-sectional studies also indicate a close association between low formal education or school dropout and low literacy in later life. Due to their crosssectional nature, the results do not clarify whether the adults have low literacy because they lack formal education or because they left school early due to their low literacy proficiency.

Furthermore, there is a strong correlation between the first language learned in childhood and low literacy proficiency in adult life. Adults who first learned a language other than German tend to have a higher risk of low literacy in German in adulthood (Grotlüschen et al., 2019). One underlying mechanism may be that individuals who grew up in non-German learning environments were confronted less often with relevant reading practices that would have helped them acquire the necessary reading-related skills (Bus, van IJzendoorn & Pellegrini, 1995; Mol & Bus, 2011). Adults with a non-German first language may also experience difficulties in literacy due to limited German language acquisition because of immigration in adulthood, restricted access to German institutions, and low educational participation (Drucks, 2013).

Practice engagement theory (Reder, 2009b) also states that the more proximal context at home and within the family shapes reading practices when carrying out functional tasks (e.g., filling out forms, communicating via messaging services, taking notes). This theory is supported by the results of the BCS (Bynner & Parsons, 2006), which indicate that women who experienced literacy proficiency losses are more likely to be single parents and that males who experienced literacy proficiency losses are more likely to have three or more children. Results from Stephen Reder's (Reder, 2009a, 2009b) LSAL of adults in the U.S. who had dropped out of high school also suggest that the presence of children or a partner can foster the development of literacy. Nienkemper and Grotlüschen (2020) argue that the presence of a partner triggers negotiation processes surrounding the fulfillment of functional tasks, thus encouraging low-literate adults to engage more often with written materials than they otherwise would.

Although international longitudinal studies strongly indicate socio-structural characteristics as significant predictors of changes in literacy in adulthood, their findings cannot be easily compared to studies conducted in a German context because of the selectivity of the samples, differences in the assessment of literacy, and the different cultural and social backgrounds in which these studies were conducted.

2.3 Age-related Declines in Basic Cognitive Abilities

Despite the central role of reading practices in shaping literacy gains and losses, psychological theories and empirical evidence additionally point to the importance of cognitive preconditions of literacy development for literacy change. In particular, the theories and evidence highlight the relevance of an individual's cognitive abilities for the development of low literacy (Eme, Lambert & Alamargot, 2014; Gasteiger-Klicpera & Klicpera, 1994; Grosche & Grünke, 2011). Disadvantaged cognitive and behavioral learning preconditions lead to a high persistence of reading difficulties. Individuals with these preconditions tend to read less because reading is more of a burden to them. Consequently, they take less advantage of opportunities to practice in school lessons and at home, in turn compounding the effect of their initial learning difficulties (Gasteiger-Klicpera & Klicpera, 1994). Low-literate adults tend to have lower levels of phonological awareness, verbal working memory, and perceptual speed for phonological information. Moreover, cognitive language disorders (phonological, semantic, or mixed) are possible risk factors for low literacy (Egloff et al., 2011; Grosche & Grünke, 2011).

Also, aging and related declines in cognitive abilities may lead to a loss of literacy proficiencies (Desjardins & Warnke, 2012; Reder, 2009b; Reder et al., 2020; Wicht et al., 2020). Most individuals reach a peak in their literacy skills at around the age of 35, after which time there is a subsequent gradual decline (Lechner, Gauly, Wicht & Miyamoto, 2020; Paccagnella, 2016). This pattern can be traced back to either cohort effects (on average, older people attended school for shorter durations) or, following the general slowing hypothesis (Cerella, Poon & Williams, 1980; Choi & Feng, 2015; McArdle, Ferrer-Caja, Hamagami & Woodcock, 2002), to biological aging (Smith, 2000). The general slowing hypothesis builds upon the theory of fluid and crystallized intelligence (e.g., Cattell, 1987; Horn & Cattell, 1967) and distinguishes between two principal dimensions of cognitive abilities: fluid (Gf) and crystallized (Gc) intelligence. Whereas Gc is considered to be shaped by an individual's education and experiences, Gf is influenced by biological factors that affect intellectual development. Gc increases

over the individual's lifespan, while Gf initially rises during the early phases of life and then declines with age.

3. The Present Study

In the present study, we cast light on the development of low literacy during adulthood. Our study is the first to use large-scale, multi-wave data to investigate patterns and predictors of (low) literacy development over time. We draw on recent data from Starting Cohort 6 ("Adults") of the German NEPS, which offer repeated measures of adults' literacy skills across a four to six-year period. These data allow us to extend previous evidence on low literacy in adulthood, which is predominantly cross-sectional. To identify the subgroup of low-literate adults in the sample, we use cut scores derived using a bookmark standard-setting procedure (Durda, Artelt, Lechner, Rammstedt & Wicht, 2020).

Our aims are twofold. First, we seek to reveal how many adults experience gains or losses in literacy that are strong enough for them to ascend from – or descend into – the defined scope of low literacy. Second, we seek to identify predictors of ascents from, and descents into, the defined scope of low literacy, along with changes in literacy (conceived as a continuous variable) within the subgroup of low-literate adults. As potential predictors, we take into account socio-demographic factors, reading practices, and cognitive abilities – factors that have been identified as potential drivers of literacy development by previous research.

4. Method

4.1 Data and Sample Definition

Starting Cohort 6 of the German NEPS (Blossfeld & Roßbach, 2019) comprises two samples, namely the original "ALWA" sample (N = 5,342) and a refreshment sample (N = 3,154) in which literacy was first assessed (T1) in 2010/11 and 2012/13, respectively. For both samples, the retest (T2) followed in 2016/17 (wave 9), which implies retest intervals of four years for the refreshment sample and six years for the original sample, respectively. We only draw on individuals with valid information on literacy at both time points (N = 5,304). Further missing data (N = 704) in predictor variables were handled using multiple imputations via a fully conditional specification (Enders, Keller & Levy, 2018). The set of variables of the imputation model equals the set of variables in the analysis models. Following Graham, Olchowski & Gilreath (2007), we used 20 imputed values. Multiple imputations were conducted with "multivariate imputation by chained equations" (mice) version 2.30 (Van Buuren & Groothuis-Oudshoorn, 2011). The final analytical sample comprises 5,304 adults aged between 24 and 69 at T1.

4.2 Measures

The literacy tests in NEPS measure reading comprehension using an approach developed by experts on literacy and psychometrics. The NEPS tests distinguish three main dimensions: Each reading test consists of five texts with different functions that are of practical relevance when handling written texts in different and typical everyday situations: information texts, commenting texts or discussion texts, literary texts, instruction texts, and advertising texts. The cognitive requirements refer to the process that participants must employ in order to solve the task and distinguish between finding information in the text, drawing text-related conclusions, and reflecting and assessing (situation model). The majority of the items are scored dichotomously (e.g., multiple choice), whereas some items have partial credit scores (e.g., decision-making tasks, matching tasks) (for further details on the assessment framework and sample items, see Gehrer, Zimmermann, Artelt & Weinert, 2012, 2013). Respondents had to complete the test in 28 minutes.

The T1 literacy test was assessed by way of a paper-pencil-based assessment and comprised 30 items (Hardt, Pohl, Haberkorn & Wiegand, 2013; Koller, Haberkorn & Rohm, 2014). At T2, the assessment mode shifted to computer-based assessment. Depending on their performance at T1, respondents received one of two booklets with varying difficulty levels that either comprise 23 or 27 items (Rohm, Scharl, Ettner & Gehrer, 2019). Using item response theory (IRT) models, NEPS provides Warm's Mean Weighted Likelihood Estimations (WLEs; Warm, 1989) of individuals' literacy skills as typical point estimates of individuals based on their item responses (i.e., "test scores"). The WLEs are on a logit scale with a mean of zero and unconstrained variance (Hardt et al., 2013; Koller et al., 2014). The overall effect of the different modes was simultaneously examined in a mode effect and linking study, and the WLEs account for the mode effect (Fischer et al., 2016; Rohm et al., 2019). In the linking study, an independent sample comparable to the main sample of NEPS SC6 in terms of relevant sociodemographic characteristics (e.g., age, educational qualification) worked on all items from the reading tests of T1 and T2 in their respective modes and under the same administrative conditions within a single measurement occasion. This independent sample was used to link the tests across the two measurement points to allow for longitudinal mean-level comparisons. Altogether, the scaling of the reading tests and the results of the mode effect and linking study exhibited good psychometric properties (including measurement invariance, reliability, linking error), thus supporting the estimation of reliable and linked literacy scores across full range of the proficiency scale. Further details regarding the psychometric properties of these tests are summarized in Hardt and colleagues (2013), Koller and colleagues (2014), and Rohm and colleagues (2019).

Based on the findings of previous studies, we selected the following variables as potential predictors of literacy development: (1) Reading practices were measured by the self-reported quantity of reading during leisure time and by the current number of books available in the household. (2) Socio-demographic characteristics included age upon first assessment of literacy, gender, educational attainment, migration background,

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Variable	Survey instrument	Time reference/ observation period	
Gender, <i>male ref.</i>		Wave 3/5	
Educational qualification	Highest school-leaving qualifications were coded with	Wave 3/5	
High (ISCED 5A + 6)	(ISCED-97).		
Medium (ISCED 4 + 5B)			
Low (ISCED 0-3)			
Age	Ascertained by information on the date of birth and the interview date.	Wave 3/5	
First language not German, German ref.	What language did you learn as a child in your family?	Wave 3/5	
Cumulative non-employment	Number of months in unemployment, retirement, house- work, parental/maternity leave, and other types of non- employment. The variable is squared to take into account that non-employment is expected to be relevant to lite- racy development from a given threshold.	Five years before first assessment of lite- racy skills to the se- cond assessment	
In a partnership, ref. no	Do you currently live together with a partner? [0] No [1] Yes	Wave 2/4	
No. of books in the household	ks in the household Approximately how many books do you have at home? As a hint: There is space for approximately 40 books on a meter of a shelf. 0 to 10 books [1], 11 to 25 books, 26 to 100 books, 101 to 200 books, 201 to 500 books, more than 500 books [6].		
Reading practice	How much time do you spend reading on average per	Wave 7	
Low (0 hours)	categorized.		
Medium (1 hour)			
High (2–4 hours)			
Reasoning The assessment is based on the matrices test (NEPS- MAT); the scale corresponds to a sum score of 12 items (Haberkorn & Pohl, 2013).		Wave 7	
Cognition speed The assessment is based on the Picture Symbol Test (NEPS-BZT); the scale corresponds to a sum score of 93 items (Haberkorn & Pohl, 2013).		Wave 7	

Tab. 1: Overview of predictor variables and how they are measured

cumulative non-employment, and living together with a partner. (3) Cognitive abilities included reasoning (fluid intelligence) and processing speed (Haberkorn & Pohl, 2013). Table 1 provides a detailed overview of all predictor variables used in our analyses, along with how and when they were measured in NEPS.

4.3 Identifying Low-Literate Adults

In order to investigate descents from higher literacy into low literacy or ascents from low literacy to higher literacy, it was essential to define a meaningful cut score that splits the sample into two proficiency groups with low literacy vs. higher literacy. For this purpose, we draw on the bookmark procedure, one of the most frequently used methods for standard setting due to its "logical appeal and practicality" (Karantonis & Sireci, 2006). According to this method, the reading items were presented in an "ordered item booklet" in which the reading items were arranged according to their item difficulty, as determined by the IRT scaling model (Hardt et al., 2013). In cooperation with experts, including test developers and professionals working with large-scale assessments and reading comprehension tests in Germany, we repeatedly compared the reading items with a priori developed performance level descriptors that guided the standard-setting process to set the cut score "bookmark" between the items marking the boundary between the lowest reading proficiency level and a functional level of literacy (for details on the procedure, see Durda, Artelt, Lechner, Rammstedt & Wicht, 2020). To determine the cut score in T2, we used the cut score derived from the bookmark procedure in T1 and assigned it to the second measurement point as the literacy scores are linked with each other (Fischer, Rohm, Gnambs & Carstensen, 2016). Since the bookmark procedure is not free of criticism in terms of its validity (for the review, see Beretvas, 2004; Karantonis & Sireci, 2006; Lin, 2006), the cut score was cross-validated in two ways: In a study by Durda, Gauly, Buddeberg, Lechner and Artelt (2020), the subgroup of lowliterate readers in NEPS was compared to the Level One Study and PIAAC. The results of these analyses showed that the subgroups of low-literate adults are highly comparable across all three surveys in terms of central sociodemographic and socioeconomic factors. Moreover, Durda, Gnambs and Artelt (2020) compared the cut score derived from the bookmark procedure with a mixed Rasch model, resulting in a relatively high agreement in the proficiency assignment of the respondents. Overall, both studies provided evidence for the validity of the cut score used in this study.

Table 2 shows basic descriptive statistics on the total sample and the sample of lowliterate adults and higher-literacy adults. Both subsamples, wave 3 and wave 5, covered a wide range of the ability distribution. However, the wave 5 refreshment sample showed lower literacy skills compared to the initial wave 3 sample and, thus, a higher proportion of low-literate adults was observed in wave 5. As Hammon Zinn, Aßmann & Würbach (2016) report, participants in the wave 5 refreshment sample were more representative of the German adult population in terms of sociodemographic characteristics.

4.4 Data Analytics Strategy

Our analyses comprised a descriptive part and an explanatory part. In the descriptive part, we examined the frequency of change in low literacy (i.e., descents into low literacy and ascents from low literacy). In order to depict the share of individuals who ex-

	Mean/percent (SD)					
	Overall	N	Higher lite- racy	N	Low lite- racy	N
Literacy skills t0	0.00 (1.31)	5,304	0.21 (1.15)	4,866	-2.31 (.48)	438
Literacy skills t1	0.01 (1.03)	5,304	0.12 (1.00)	4,866	-1.15 (.69)	438
Type of sample		5,304				438
Wave 3	62.03	3,290	63.60	3,095	44.52	195
Wave 5	37.97	2,014	36.40	1,771	55.48	243
Gender		5,304		4,866		438
Male	49.42	2,621	48.77	2,373	56.62	248
Female	50.58	2,683	51.23	2,493	43.38	190
Educational qualification		5,303		4,865		438
High (ISCED 5A + 6)	30.47	1,616	32.64	1,588	6.39	28
Medium (ISCED 4 + 5B)	28.37	1,505	29.21	1,421	19.18	84
Low (ISCED 0-3)	41.14	2,182	38.14	1,856	74.43	326
Age	32.24 (9.26)	5,304	47.70 (10.66)	4,866	52.83 (10.81)	438
First language		5,301		4,863		438
German	95.21	5,050	95.81	4,659	89.27	391
Not German	4.73	251	4.19	204	10.73	47
Cumulative non-employment	26.79 (40.35)	5,183	24.46 (38.60)	4,760	53.01 (49.34)	423
In a partnership				4,765		432
No	24.11	1,253	23.80	1,134	27.55	119
Yes	75.89	3,944	76.20	3,631	72.45	313
No. of books in the household	4.16 (1.30)	5,204	4.26 (1.26)	4,781	3.10 (1.27)	423
Reading practice		5,061		4,650		411
Low (0 hours)	8.52	431	8.15	379	12.65	52
Medium (1 hour)	56.67	2,868	56.58	2,631	57.66	237
High (2–4 hours)	34.82	1,762	35.27	1,640	52	122
Reasoning	8.30 (2.70)	4,813	8.55 (2.55)	4,427	5.47 (2.77)	386
Cognition speed	32.24 (9.26)	4,816	32.86 (8.94)	4,429	25.13 (9.89)	387

Tab. 2: Basic descriptive statistics of the analytical sample

perienced a statistically significant change in literacy from T1 to T2, we computed the reliable change index (RCI) for IRT models as described by Brouwer, Meijer & Zevalk-ink (2013). The RCI aims to identify the share of respondents who experience a "reliable" change in outcome, with "reliable" defined as a change that significantly exceeds the size of typical (random) fluctuations between two time points. To that end, the RCI expresses change between two measurement occasions relative to the standard error of measurement of the difference score (Brouwer et al., 2013):

$$Z = \frac{\hat{O}_2 - \hat{O}_2}{\sqrt{SE_2^2 + SE_1^2}}$$

The RCI is thus a more conservative measure of change than simple raw difference scores; it separates reliable, significant change in literacy from small fluctuations that are ultimately not meaningful. For our descriptive analyses, we only classified individuals as experiencing descents into, or ascents from, low literacy if the following two conditions were met: (1) respondents experienced a change in literacy that led them to cross the threshold (i.e., cut score) of low literacy; and (2) the level of change was significant according to the RCI values. This means that respondents who crossed the cut score only because of small fluctuations in literacy were not classified as joining or leaving the subgroup of low-literate adults.

In the explanatory part of our analyses, we investigated potential risk and protective factors for changes in low literacy in two complementary ways. First, we used logistic regression models predicting descents from higher literacy to low literacy as well as ascents from low literacy to higher literacy. Again, we considered previous literacy to account for individuals' distance to the defined cut score of low literacy. In all models, we considered whether individuals belonged to the initial sample or the refreshment sample via a binary indicator. Second, we examined predictors of change in literacy over time within the subgroup of low-literate adults. To this end, we use a difference-score approach (Imbens & Wooldrige, 2009) that models literacy at T2 minus literacy at T1, as a function of previous literacy (T1) and a vector of potential predictors of literacy development³:

$$Literacy_{i, \Delta_{t1}^{t2}} = \beta_0 + \beta_1 Literacy_{i, t1} + \beta X + e_i$$

³ We have also calculated models without controlling for literacy at T1. The results do not differ significantly from those presented in the manuscript and are available upon request from the corresponding author.

4.5 Selectivity Analyses

Due to a large number of missing values in literacy at T2, we scrutinized whether dropout was random or systematic. We identified predictors of nonresponse at T2 by regressing a binary indicator of dropout (0 = no dropout, 1 = dropout) on the variables used in our analysis model that were assumed to be relevant to dropout (literacy at T1, sample type, gender, first language and educational qualification). Our results showed that participants with lower literacy scores at T1 were more likely to refuse further participation than participants with higher ones, which was in line with recent findings in earlier waves of NEPS and PIAAC-L (Martin, Lechner, Kleinert & Rammstedt, 2020). Moreover, higher dropout was observed for participants whose first language was not German and who had only low educational qualification. Gender and sample type (original vs. refreshment) showed no effects. Even though these analyses revealed that dropout at T2 was not random, the fact that dropout could be well predicted by covariates in our analysis model means that a missing at random conditionally on covariates (MAR) is a plausible assumption for the missing data mechanism. Furthermore, to ensure that the original sample at T1 does not differ from the sample at T2 with respect to literacy, we compared the literacy scores at T1 of the original and the analytic sample for both the low literacy and the literacy group. We found no significant differences between the two samples (Cohen's d < .20). The results of our selectivity analyses are available upon request from the authors.

5. Results

5.1 How Frequent Are Ascents From, and Descents Into, Low Literacy?

We start our descriptive analyses by looking at the share of individuals who registered literacy gains or losses over time that were high enough to ascend from, or to descend into, levels of literacy defined as 'low,' i. e., individuals who crossed the cut score of low literacy in an upward or downward direction. The results presented in Figure 1 refer to statistically significant intra-individual changes from one measurement occasion to the next as per individuals' RCI values.

Comparing the two pillars of Figure 1, the share of low-literate adults in the sample decreased from 8.3 percent (n = 440) to 6.2 percent (n = 328). Of those adults classified as 'low-literate' at T1, 32 percent ascended to higher literacy levels at T2. By contrast, only 0.6 percent of those classified as having higher literacy levels at T1 crossed the cut score and descended into low literacy at T2. These descriptive results suggest that 'low literacy' is a highly, but not perfectly, stable characteristic over a time span of four to six years of adulthood. Moreover, they suggest that ascents from low literacy are much more prevalent than descents into low literacy during the observation period in this sample.



Percentages refer to reliable changes. NEPS Starting Cohort 6, DOI:10.5157/NEPS:SC6:9.0.1. N = 5,304.

Fig. 1: Ascents from and descents into low literacy in adulthood

5.2 What Predicts Ascents From and Descents Into Low Literacy?

Moving to the explanatory part of our analyses, we next examined whether sociodemographic characteristics, reading practices, and cognitive abilities predict these ascents from and descents into low literacy levels. Figure 2 shows the results of our logistic regression models predicting ascents from low literacy to higher literacy (vs. remaining below the cut score defining low literacy). For an easier interpretation of the results, we report average marginal effects (AME) instead of logistic regression coefficients. AMEs express the effect sizes of each predictor in percentage points of the outcome (i.e., descents or ascents). With our set of predictors, we are largely unable to explain ascents from low literacy to higher literacy. The highest pseudo-R² was about .05, meaning that only five percent of the explained variance of ascending from low to higher literacy could be explained by all predictors in the model. While sociodemographic characteristics play no part in ascending from low literacy to higher literacy (Model 1), the number of books available in the household stands out as a driver of literacy gains that are high enough to ascend from low literacy to higher literacy (Model 2). If the number of books at home is one standard deviation higher, it increases the probability of ascending from low literacy to higher literacy by five percentage points (p = .029). This effect remains stable after introducing cognitive abilities unrelated to the likelihood of ascents from low to higher literacy (Model 3). Men are slightly more likely (p = .04) to ascend from low literacy to higher literacy than women.



Average marginal effects and 95 percent confidence intervals of logistic regression models. NEPS Starting Cohort 6, DOI:10.5157/NEPS:SC6:9.0.1. Controlling for initial literacy and sample type: six-year or four-year retest interval. Continuous variables were z-standardized. No. of cases with valid information on all variables N = 438.

Fig.2: Predictors of ascents from low literacy to higher literacy

Figure 3 shows the results of logistic regression models predicting descents from higher literacy into low literacy (vs. remaining above the cut score defining low literacy). In contrast to ascents to higher literacy, descents into low literacy can be predicted quite well as measured by the Pseudo- R^2 (.17 in Model 1 to .21 in Model 3). Looking at the results for sociodemographic characteristics, low-educated adults are more likely than high-educated adults ($\beta = 0.025$; p = .004) and non-German first language speakers are more likely than native speakers ($\beta = 0.045$; p = .006) to descend into low literacy. Also, cumulative non-employment ($\beta = 0.006$; p = .002; squared term) and age ($\beta = 0.009$; p =.000) predicted descents into low literacy. The effects remained stable after introducing reading practices (Model 2). The coefficient of a lower educational qualification versus a higher one, however, decreases by one percentage point. As for the previous analyses, the number of books in the household protects adults from descending into low literacy $(\beta = -0.01; p = .000)$. When including cognitive abilities (Model 3) which do not incrementally predict descents into low literacy, the initial effect of age is reduced by 0.5 percentage points. However, age remains a statistically significant predictor of descents from higher literacy to low literacy ($\beta = 0.008$; p = .007).



Average marginal effects and 95 percent confidence intervals of logistic regression models. NEPS Starting Cohort 6, DOI:10.5157/NEPS:SC6:9.0.1. Controlling for initial literacy and sample type: six-year or four-year retest interval. Continuous variables were z-standardized. No. of cases with valid information on all variables N = 4,866.

Fig. 3: Predictors of descents from higher literacy to low literacy

5.3 What Predicts Change in Literacy in the Subgroup of Low-Literate Adults?

Zooming in on literacy development within the subgroup of low-literate adults, we finally examined how sociodemographic characteristics, reading practices, and cognitive abilities relate to literacy development within the subgroup of low-literate adults. Adopting a stepwise approach, we first introduced sociodemographic characteristics, followed by reading practices and then cognitive abilities.

Figure 4 shows the results of our difference score approach analyzing the (continuous) change in literacy within the subgroup of adults who were classified as having low literacy at T1 (n = 440). All continuous variables, including the dependent variable, were z-standardized such that their regression coefficients express changes in literacy in standard deviations following a one standard deviation increase in the predictor.

Model 1 shows that, among the sociodemographic characteristics included in the model, only age was significantly related to changes in literacy within the group of low-literate adults. An increase of one standard deviation in age (approximately ten years) leads to a decrease in literacy by 0.08 standard deviations (p = .021). Considering reading practices in Model 2 revealed that a higher number of books in the household



Point estimates and 95 percent confidence intervals of lagged dependent variable models. NEPS Starting Cohort 6, DOI:10.5157/NEPS:SC6:9.0.1. Controlling for initial literacy and sample type: six-year or four-year retest interval. Continuous variables were z-standardized. No. of cases with valid information on all variables N = 438.

Fig. 4: Predictors of changes in literacy among low-literate adults

predicted literacy gains ($\beta = 0.11$; p = .004). Also, the regression weight for age increased slightly over Model 1 ($\beta = -0.11$; p = .004). Moreover, the regression weight for gender became statistically significant, indicating that men tend to register literacy gains more often. However, the 95 percent confidence intervals were quite broad ($\beta = -0.15$; p = .03). Remarkably, after introducing individuals' cognitive abilities in Model 3, the association of age shrank substantially and was no longer statistically significant. Notably, individuals' reasoning (i.e., fluid intelligence) appeared to be a driver of literacy gains in adulthood ($\beta = 0.13$; p = .000).

6. Summary and Discussion

Given the persistently high number of low-literate adults in Germany and around the globe, it is highly relevant to researchers, policymakers, and practitioners alike to establish the extent to which (low) literacy can change during adulthood – and to identify risk and protective factors that explain potential changes in (low) literacy over time. In this study, we utilized the potential of recent large-scale data from NEPS, which include

repeated measures of adults' literacy skills spanning up to six years of adulthood. First, we gauged the share of adults who experience literacy gains and losses that are high enough to ascend from or descend into the defined domain of low literacy. To this end, we defined a cut score that splits the sample into two proficiency groups with low vs. higher literacy using the bookmark procedure, and reported reliable changes according to the RCI, a conservative measure of change. Second, drawing on the insights of previous research on (low) literacy, we identified predictors of such descents from higher literacy to low literacy and ascents from low literacy to higher literacy, as well as predictors of literacy gains and losses within the group of low-literate adults.

Our analyses reveal that low literacy is not an immutable characteristic, even across a relatively short period of up to six years of adulthood. Instead, low literacy appears to be a condition that is fundamentally malleable, with ascents from low literacy to higher literacy more prevalent in our sample than descents from higher literacy to low literacy. While 32 percent ascended from low literacy to higher literacy, only 0.6 percent descended from higher literacy to low literacy. In addition, low literacy responds to cognitive abilities and sociostructural factors and, in particular, to reading practices. However, while we were able to explain descents from higher literacy to low literacy quite well with our set of predictor variables, our analyses fall short in explaining changes in literacy among low-literate adults as well as ascents from low literacy to higher literacy. Consequently, our analyses do not provide a clear picture and we were only able to identify a few predictors that are consistently decisive across all analyses.

Our explanatory analyses suggest that reasoning (i.e., fluid intelligence) is associated with literacy gains among low-literate adults. Also, individuals' reasoning negatively correlates with age predicting literacy losses. These results underpin the findings of previous cross-sectional research on observed literacy skills based on an individual's age. While we cannot completely rule out various diseases as the cause of age-related losses in literacy, the finding supports the general slowing hypothesis which suggests that age-related slowing is responsible for declines in literacy with increasing age. Also, our analyses for descents from higher literacy to low literacy identified age and age-related declines in cognitive abilities as an essential risk factor of low literacy. By contrast, neither individual differences in age nor reasoning are associated with ascents from the defined domain of low literacy to higher literacy.

Besides these age-related and cognitive factors, reading practices, especially gauged by the number of books in the household, have consistently been a significant predictor of literacy development in adulthood. The number of books in the household is a catchall proxy of reading practices, as evidenced by its robust association with a range of practices such as reading books, reading the news, visiting libraries, or attending cultural events (Sieben & Lechner, 2019). Reading practices as measured with this indicator not only predicted gains in literacy skills of low-literate adults but also seem to enable adults to ascend from the defined domain of low literacy to higher literacy. In this respect, our findings are in line with previous studies that found a positive relationship between reading practices and changes in literacy in adulthood (Reder et al., 2020; Wicht et al., 2020). Likewise, reading practices appear to be an important protective factor of descending from higher literacy to low literacy. Therefore, in line with cognitive learning theories in general and practice engagement theory in particular, stimulating environments to engage with reading practices pay off in terms of literacy gains. In contrast to the findings of previous research, the family context, as measured by the availability of a partner, has proven to be a non-decisive factor in literacy development.

Our analyses for descents from higher literacy to low literacy also revealed sociodemographic characteristics indicating that high resources are crucial protective factors of low literacy. These characteristics include employment, high formal education, and German as the first language. This finding is consistent with previous research on literacy development in general and low literacy in particular. It can be interpreted in terms of a 'Matthew effect,' according to which educational inequalities become further magnified over an individual's lifetime. Socially advantaged individuals are expected to be exposed to stimulating learning environments more often, resulting in a literacy gap between them and their less advantaged counterparts.

In line with the assumption of a lifelong plasticity of skills (Kessler & Staudinger, 2006), our study demonstrates that low literacy in adulthood is fundamentally malleable. At the same time, it partly confirms the findings of previous research and theorizing on (low) literacy, identifying one fundamental underlying mechanism for literacy development in adulthood that is common to all analyses: reading practices.

7. Limitations to and Directions for Future Research

The strength of our study lies in its use of large-scale representative data with a repeated measurement design of the assessment of literacy skills in adulthood. However, it is not without limitations that should be addressed by future research. First, the database we used only allows us to analyze the change in low literacy over two measurement occasions spanning four to six years in adulthood, and most predictor variables are only surveyed once. Analyzing the temporal dynamics of change in low literacy requires more extensive longitudinal data with additional measurement occasions of literacy and relevant predictor variables (e.g., reading practices). Such data would allow for more persuasive causal claims concerning the risk and protective factors of low literacy over one's lifetime. Second, we were less able to explain ascents from low literacy to higher literacy than descents from higher literacy to low literacy. Further research is required to reveal the predictors of change in literacy relevant to the specific group of initially lowliterate adults. Low literacy adults might be especially sensitive to status changes (e.g., a new life partner, a newborn child), prompting changes in reading practices that cannot be sufficiently depicted with the data used. Third, as our study points to the pivotal role of reading practices for low literacy, future studies might profit from a more in-depth analysis of the relevance of these practices. Unfortunately, the NEPS measures for reading practices available to us were quite broad. Nevertheless, our study is a first attempt to shed light on the risk and protective factors of low literacy in adulthood.

8. Conclusion

Low literacy is not an immutable condition in adulthood but has the potential to change over an individual's lifetime. Our analyses of change in low literacy during up to six years of adulthood demonstrate that ascents from low literacy to higher literacy are possible – almost a third of low-literate adults experienced gains in literacy that were strong enough to lift them above the cut score and out of 'low' literacy. We identified reading practices measured by the number of books in the household as protective factors of low literacy consistently throughout our analyses. Consequently, policies and interventions should focus on reading practices as promising vehicles for coping with low literacy in adulthood.

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Zusammenfassung: In den meisten Industriegesellschaften sind etwa 10-15% der Erwachsenen nur in der Lage, auf dem Grundniveau zu lesen, ein Phänomen, das gemeinhin als ,geringe Literalität' bezeichnet wird. Diese Studie befasst sich mit zwei Fragen zur Entwicklung der geringer Literalität im Erwachsenenalter: (1) Wie stabil ist die geringe Literalität bei Erwachsenen, d.h. wie groß ist der Anteil Erwachsener, die einen Aufstieg von oder einen Abstieg in den Definitionsbereich geringer Literalität erleben? (2) Welche Risiko- und Schutzfaktoren sagen solche Auf- und Abstiege sowie die Veränderungen von Literalität innerhalb der Gruppe gering literalisierter Erwachsener voraus? Wir verwenden repräsentative Daten des Nationalen Bildungspanels (NEPS), das wiederholte Messungen der Literalität Erwachsener über einen Zeitraum von vier bis sechs Jahren bereitstellt. Wir identifizierten Erwachsene mit geringer Literalität auf der Grundlage eines Cut-Scores, der mit der Bookmark-Methode ermittelt wurde. Wir stellten fest, dass Aufstiege von geringer Literalität zu höherer Literalität häufiger waren als Abstiege von höherer Literalität zu niedriger. Fast ein Drittel der Erwachsenen mit niedriger Literalität stieg nach vier bis sechs Jahren von niedriger Literalität zu einer höheren Literalität auf. Die Lesepraxis erwies sich als wichtigster Schutzfaktor gegen einen Abstieg in geringe Literalität und prognostizierte eine Zunahme von Literalität innerhalb der Gruppe der gering literalisierten Erwachsenen. Insgesamt deutet unsere Studie darauf hin, dass geringe Literalität kein unveränderlicher Zustand im Erwachsenenalter ist, sondern sich im Laufe des Lebens verändern kann, was bedeutet, dass bei Erwachsenen mit niedriger literalität im Laufe der Zeit tatsächlich Literalitätszuwächse möglich sind.

Schlagworte: Geringe Literalität, Entwicklung von Literalität, Large-scale Assessment, Erwachsene, Nationales Bildungspanel

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