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The Relationship Between Reading Skills and Intelligence in Students With and Without Special Educational Needs in Learning

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Reading research shows that phonological decoding skills and intelligence work mostly independent from each other. However, there is a variety of results on the relationship between reading skills and IQ measures. Studies in this field mainly focus on students with reading disabilities (RD) or students with intellectual disabilities (ID) and less on pupils with Special Educational Needs in Learning (SEN-L). We performed a secondary data analysis to evaluate differences in reading skills and fluid intelligence between students with (N = 144) and without (N = 157) SEN-L and the relationship between SEN-L, reading skills, and fluid intelligence. Participants completed a standardized screening of reading skills (SLS 2-9) and a German culture fair intelligence test (CFT 20-R). Students with SEN-L had lower scores in both tests. Correlations between both scores were smaller within the two groups than in the total sample. Implications of the findings are discussed.

Keywords: reading skills, fluid intelligence, Special Educational Needs, secondary data analysis, Germany

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INTRODUCTION

Special Educational Needs in Learning (SEN-L) are the most prevalent type of SEN in Germany: Regularly, about 2.45% of all students are officially diagnosed as having SEN-L in the academic year 2017/18 (Kultusministerkonferenz, 2019b,c). Most of the federal states in Germany define SEN-L according to the guidelines provided by the conference of the state ministers for education (Kultusministerkonferenz, 2019a).[1] These guidelines suggest that SEN-L can be diagnosed if a student fails to achieve the minimal standards of the regular curriculum for a longer period despite adequate individual support provided by the regular education system (Kultusministerkonferenz, 2019a, p. 8). Despite this, some of the federal states use the criterion of an IQ between 85 and 70 (borderline intellectual functioning) as the criterion to distinguish students with SEN-L from "garden variety" poor learners on the one hand and students with intellectual disabilities (ID) on the other hand. In the German school system, SEN-L is distinguished from learning disabilities (LD) as defined by the WHO, such as reading learning disability (RD), or dyslexia. More detailed information on the system of special needs education in Germany can be found in Kocaj et al. (2018) and Sansour and Bernhard (2018).

[1]The Kultusministerkonferenz is the panel where the ministers for education of all German federal states discuss and develop common guidelines. These guidelines are tentative recommendations.

Reading research suggests that phonological decoding and intelligence mostly work independent from each other (Stanovich, 1988). It is argued that an IQ discrepancy criterion should be irrelevant for the diagnosis of RD as problems in reading skills do not differ between students with discrepant RD and non-discrepant RD (Stanovich et al., 1984; Stanovich, 1988, 1991a,b; Siegel, 1989a,b, 2016; Tønnessen, 1995; Gustafson and Samuelsson, 1999; Klicpera and Gasteiger Klicpera, 2001; Scarborough and Parker, 2003).

However, there is a huge base of research on the relationship of reading skills and intelligence. Research on the correlation of both show a big variance from close to zero up to 0.80 (Bishop and Butterworth, 1980; Schulte and Borich, 1984; Stanovich et al., 1984; Carver, 1990; Naglieri, 1996, 2001; Naglieri and Ronning, 2000; Vellutino, 2001; Cotton and Crewther, 2009). A potential explanation for this variances are differences in the assessments used as well as focusing on different aspects of the two constructs, e.g., verbal measures of intelligence are higher correlated to reading ability than nonverbal measures (Cotton and Crewther, 2009).

Furthermore, intelligence seems to predict reading abilities especially in the context of early literacy and of RD (de Jong and van der Leij, 1999; Tiu et al., 2003; Bowey, 2005; Kortteinen et al., 2009).

All these findings on the relation between intelligence and reading have been obtained with normal readers or persons with RD but not with persons with SEN-L (which is associated with a borderline intellectual functioning and severe learning difficulties in all areas of academic achievement). Despite the fact that students with SEN-L are not students with ID (IQ < 70), some evidence on students with SEN-L could carefully be drawn from research on students with ID: According to Euker (2018) most studies can't find a relationship between IQ and reading abilities in students with ID (Cohen et al., 2001; Conners et al., 2001; Katims, 2001; Conners et al., 2006). However, intelligence influences the learning progress in reading trainings for students with ID (Allor et al., 2014). For the German context, the study by Euker (2018) suggests evidence for the efficacy of a reading training for students with ID with no significant relationship between intelligence and the training outcomes.

Taken together, there is little knowledge about the relation of (fluid) intelligence and reading skills in students with SEN-L, although IQ is used as a criterion for the diagnosis of SEN-L. The current paper aims to fill this gap using a dataset from the project "How to design educational material for inclusive classrooms" (Noll, 2020; Noll et al., 2020). The following research questions are surveyed:

1. Is there a difference between students with and without diagnosed SEN-L regarding reading skills and fluid intelligence?
2. Does diagnosed SEN-L have an impact on the correlation between reading skills and fluid intelligence?
3. Are reading skills and fluid intelligence good predictors for diagnosed SEN-L?

METHODS

Dataset for Secondary Analysis

To contribute mentioned desiderata, we performed a secondary analysis of data from the project "How to design educational material for inclusive classrooms" (Noll, 2020; Noll et al., 2020).

Participants

Students from 24 classes out of 12 different schools with 4 different organizational forms [9 special needs schools for students with SEN-L; 2 inclusive schools; and one Realschule (middle-school)] in the State of Rhineland-Palatinate participated in the initial study. Due to the mathematical background of the original project the main inclusion criteria was that rational numbers had not been part of the curriculum in all the participants' previous school biography. Also, written consents from all students and parents had to be present. Data collection procedures were approved by the Commissioner for Data Protection and the Supervision and Service Administration Body of the state. The sample size was $N = 303$ in total. Within the sample $N = 144$ students were diagnosed with SEN-L. The other 159 participants did not have any Special Educational Needs. **Table 1** summarizes the main properties of the sample: On average, participants with SEN-L were about 1 year older than participants without SEN-L. Because of varying curriculums and due to different organizational forms, the age of the participants varied from 9 to 14 years ($M_{age} = 11.1$, $SD_{age} = 1.04$).

Procedures

Data were collected directly in the classrooms in a 90-min sequence. In a 15-min introduction, potential participants were informed about the initial project and the procedure of data collection. The examiner (a Ph.D. student from the project "How to design educational material for inclusive classrooms") stressed the fact that participation was voluntary and that results had no effect on their school career or grades. Also, full anonymization was guaranteed. Subsequently fluid intelligence was measured with part 1 of the "Grundintelligenztest Skala 2 – CFT 20-R" (Weiß, 2006) administered as group test with prolonged test-time (40-min) to accommodate the pupils with SEN-L as stated in the manual. After that the participants had a 10-min break bevor taking the "Salzburger Lese-Screening für die Schulstufe 2-9–SLS 2-9" (Wimmer and Mayringer, 2014) to test

TABLE 1 | Participants gender and age stratified by SEN-L.

	SEN-L		
	Yes	**No**	***p***
N	144	159	
Age [mean (*SD*)]	11.76 (1.02)	10.50 (0.63)	<0.001
Gender = male (%)	73 (50.7)	89 (56.0)	0.421

No significant difference in gender [$\chi^2(1) = 0.648$, $p = 0.421$], significant difference in age [$t(232.64) = 12.751$, $p < 0.001$,Welch correction used for t-test] between groups.

TABLE 2 | Descriptive Statistics and independent sample *t*-test for group differences in fluid intelligence and reading skills.

	N	*M*	*SD*	*SE*	Min	Max	*t*	*df*	*d*
Fluid intelligence (CFT 20R)							12.91***	301	1.49
Students with SEN-L	144	75.60	16.95	1.41	40	112			
Students without SEN-L	159	99.47	15.21	1.21	57	141			
Total sample	303	88.13	19.99	1.15	40	141			
Reading skills (SLS 2-9)							9.95***	288.63	1.15
Students with SEN-L	144	64.06	21.88	1.82	0	119			
Students without SEN-L	159	87.91	16.62	1.56	0	130			
Total sample	303	76.57	23.88	1.37	0	130			

*All test scores standardized based on age norms (CFT 20-R) or class norms (SLS 2-9) with M = 100 and SD = 15. Welch correction for df used in the t-test for SLS. *p < 0.05, **p < 0.01, and ***p < 0.001.*

their basic reading ability. The SLS 2-9 was also administered as a group test.

Instruments

The CFT 20-R (Weiß, 2006) is a German culture fair intelligence test. It is based on the theory of fluid and crystallized intelligence (Cattell, 1963) and measures general fluid intelligence using four different subtests (pattern reasoning, classification, matrices, and topologies) utilizing abstract symbols and yielding the use of language. The test can be administered as a group test for children and adolescents between 8; 5; and 19 and up to 60 years for part 1. Reliability for the administered part 1 of the test is high ($r = 0.92$). Test-retest correlations vary from 0.69 (students with SEN after 5 months) to 0.85 (students from mainstream schools after 2 months). Medium to high correlations ($r = 0.60$ to $r = 0.75$) with other construct related intelligence tests (PSB subtests 2, 3, 4; Raven; IST and FAT) speak for the validity of the instrument. The CFT 20-R is scored on an IQ scale with age norms ($M = 100$; $SD = 15$).

The SLS 2-9 (Wimmer and Mayringer, 2014) is a time efficient (group) screening measure assessing basic reading comprehension skills in children and adolescents from grades 2 to 9. Participants are asked to give a true or false statement about simple sentences. The raw score is the number of correct answers given within a 3-min period. Reliability (parallel test) ranges from 0.87 for grade 8 to 0.95 for grade 2 students. According to the manual validity analyses show that low results in the SLS 2-9 are linked to more and longer fixations of single words in gaze-tracking studies. Convergent Validity with the more extensive ELFE II is high ($r_{ct} = 0.77$; Lenhard et al., 2018). The SLS 2-9 is scored on a standardized scale with class norms ($M = 100$; $SD = 15$).

Data Analysis

Data analysis was done using GNU R (R Core Team, 2019). Descriptive statistics were calculated using the *psych*-package (Revelle, 2018).

To answer research question (1) we compared the results of students with and without SEN-L using independent *t*-tests. Welch-correction was used if Levene's test indicated that assumption of homogeneity of variances was violated. Cohen's *d* was calculated using the *effsize*-package (Torchiano, 2019). Research question (2) was evaluated using Pearson correlations.

For research question 3, logistic regression (Long, 1997; Field, 2015) with SEN-L as dependent variable and with reading skills and fluid intelligence as predictor variables was performed using the glm-function in Gnu R. Model χ^2 was computed using the lrtest-function from the *lmtest*-package (Zeileis and Hothorn, 2002). As a goodness-of-fit index we calculated pseudo R^2 as introduced by Cox and Snell (1989) and Nagelkerke (1991) using the PseudoR2-function from the *DescTools*-package (Signorell et al., 2020).

RESULTS

As displayed in **Table 2** we could show that students without SEN had significantly higher fluid intelligence ($d = 1.49$) as well as significantly better reading skills ($d = 1.15$) than their peers with SEN-L. Within the total sample, reading skills, and fluid intelligence were strongly positively correlated with $r(301) = 0.51$, $p < 0.001$. Splitting the sample into the two groups (students with SEN-L vs. students without SEN) resulted in reduced correlations of $r(157) = 0.33$ (students without SEN; $p < 0.001$), and $r(142) = 0.31$ (students with SEN-L; $p < 0.001$).

To analyze if reading skills and fluid intelligence have an impact on the probability to be diagnosed as having a SEN-L, we used logistic regression with the grouping factor SEN-L as dependent variable and with reading skills and fluid intelligence as predictor variables (see **Table 3**). With pseudo $R^2 = 0.407$

TABLE 3 | Coefficients with 95%-CI of the model predicting whether a student has been diagnosed with SEN-L.

	b	*SE*	OR
Constant	−0.044	0.155	0.957
	(−0.347; 0.262)		(0.707; 1.300)
Fluid intelligence	−1.612***	0.239	0.200
	(−2.109; -1.171)		(0.121; 0.310)
Reading skills	−0.954***	0.214	0.385
	(−1.396; −0.553)		(0.248; 0.575)

*$R^2 = 0.407$ (Cox and Snell) 0.543 (Nagelkerke). Model $\chi^2(1) = 158.14$, $p < 0.001$. −2LL = 261.16 (df = 300). b = beta coefficient, SE = standard error of beta value, and OR = odds ratio. *p < 0.05, **p < 0.01, and ***p < 0.001. Variables scaled to M = 0 and SD = 1 before regression.*

(Cox and Snell) and pseudo $R^2 = 0.543$ (Nagelkerke) the model predicts the diagnosis of SEN-L quite well.

DISCUSSION

The finding that the two groups perform differently in measures of reading and fluid intelligence was not surprising. However, due to the unclear definition and diagnostic criteria of SEN-L in Germany this was not self-evident. **Table 2** shows an apparent amount of overlap in the scores between the groups. Therefore, it seemed necessary to check this difference before further analysis.

We could find medium correlations between reading skills and fluid intelligence in both groups. These correlations did not differ between the two groups ($z = -0.19$, $p = 0.42$).

These findings for students with SEN-L are congruent to the findings for regular students as they are reported in the introduction. This provides first evidence that findings from the general population regarding the relationship between reading and intelligence might be transferred to the group of pupils with SEN-L and that fluid intelligence does not seem to be the main factor to explain reading difficulties in pupils with SEN-L. Also, the results of our analysis question the role of IQ measures in diagnosing SEN-L. The findings suggest that reading education for SEN-L students should be like established recommendations based on RD in general. We would argue for using the actual learning progress as the best indicator for educational decision making in an evidence-based reading program instead of IQ measures. If standardized evidence-based measures of reading instruction do not lead to sufficient learning progress, individualized support can be applied.

Furthermore, according to the results for research question 3, in a logistic regression reading skills and fluid intelligence worked quite well as predictors for the diagnosis of SEN-L. With increasing level of fluid intelligence and reading skills the chance of being diagnosed with SEN-L decreases significantly. However, if taking reading skills and fluid intelligence as a hard criterion for severe learning problems, it can be assumed that a substantial numbers of actual SEN-L diagnoses are false positives. This finding, which is congruent to Kottmann (2006), is problematic, because in the German school system this diagnosis has an important impact on school career with strong restrictions for possible graduations and choices of vocation.

Altogether, our data suggests that general findings from populations without SEN concerning the relationship between fluid intelligence and reading skills might be transferred to the population of pupils with SEN-L. For the practical service for pupils our analysis strengthens evidence to not overestimate the role of (fluid) intelligence for diagnostic decisions.

LIMITATIONS

Although the number of participants to answer our questions is statistically sufficient, limitations to the generalization of our findings may arise due to the sampling process which was based on classes' mathematical background knowledge instead of sociodemographic data. Also, for pupils with SEN-L the measurement of intelligence and reading via a group-tests might not be ideal. Test accommodation for pupils with not apparent additional special needs could not be guaranteed within the reading measure.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: We do not have permission to share the full dataset. Requests to access these datasets should be directed to Anna Noll, noll@uni-landau.de.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MS and DS developed the research questions, planned the data analysis, did the interpretation of the results, drafted the introduction, discussion, and limitation sections, and edited the final manuscript for submission. MS provided the data set from the project "How to design educational material for inclusive classrooms" and drafted the methods section (excluding data analysis). DS did the data analysis and drafted the data analysis subsection of the methods section. Both authors contributed to the article and approved the submitted version.

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