

RESEARCH ARTICLE

WILEY

Are different reading problems associated with different anxiety types?

Deanna A. Francis^{1,2}  | Jennifer L. Hudson² | Serje Robidoux¹  |
Genevieve M. McArthur¹

¹Macquarie University Centre for Reading, Macquarie University, Sydney, New South Wales, Australia

²Black Dog Institute, University of New South Wales, Sydney, New South Wales, Australia

Correspondence

Deanna A. Francis, Macquarie University Centre for Reading, Macquarie University, Sydney 2109, NSW, Australia.
Email: deanna.francis@mq.edu.au

Funding information

Australian Research Council, Grant/Award Number: ARC DP200102241

Abstract

There is a reliable association between poor reading and anxiety, but we do not completely understand the specifics of this relationship. The current study included a sample of children ($N = 284$; $M_{\text{age}} = 9.30$, $SD_{\text{age}} = 1.31$) who completed a reading (word, nonword, and text reading accuracy, word, nonword, and text reading fluency, passage reading comprehension) and anxiety (social anxiety, generalized anxiety, separation anxiety, physical injury fears/phobias, panic, obsessive compulsive symptoms) assessment. Analyses included bivariate and partial correlations, principal components analysis, and hierarchical clustering. We found a very tentative suggestion in the data that there may be a specific yet weak association between reading accuracy and social anxiety. The clinical implications and directions for future research are discussed.

KEYWORDS

anxiety, poor reading, reading difficulties, social anxiety

1 | INTRODUCTION

The ability to read is a critical survival skill in the modern world, yet 16% of children fall more than one standard deviation below the reading level expected for their age or grade (Shaywitz et al., 1992). These children struggle with various types of reading difficulties, including the ability to read words via the grapheme-to-phoneme correspondence (GPC) rules or whole-word recognition (“word reading accuracy”); the ability to read words and texts accurately and fluently (“reading fluency”); and the ability to understand the meanings of words and texts (“reading comprehension”). While some children with poor reading may have specific problems with just one type of reading (Castles & Coltheart, 1996; McArthur et al., 2013b; Nation et al., 2010), the majority have problems with two or more of these skills (McArthur et al., 2013b; Stuart & Stainthorp, 2016).

Anxiety is another common childhood problem that affects around 7% of children (Lawrence et al., 2015). Anxiety is an adaptive emotion that becomes problematic if symptoms are excessive, persistent, and interfere with the child's everyday life (American Psychiatric Association, 2013). Like poor reading, anxiety presents differently. For example, social anxiety includes symptoms of excessive worry in situations where there is a risk of embarrassment or negative evaluation—such as reading aloud, meeting new children, or participating in class activities (American Psychiatric Association, 2013). Generalized anxiety includes numerous and persistent worries typically about performance and competence for children—such as performing poorly at school, making mistakes, or getting into trouble (American Psychiatric Association, 2013). Separation anxiety is defined by symptoms of worry and distress when a child is away from home or their parents—such as worry that something bad will happen to their loved ones

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(American Psychiatric Association, 2013). There are also specific phobias relating to feared situations or objects, such as dogs or thunderstorms, as well as related conditions such as panic (i.e., sudden, and intense fear), and obsessive-compulsive disorder (i.e., repetitive thoughts and/or behaviors; American Psychiatric Association, 2013). As is the case for reading, most children with anxiety experience more than one type of anxiety and associated symptoms (Copeland et al., 2014; Costello et al., 2005).

1.1 | Poor reading and anxiety

Traditionally, reading and anxiety in children have been studied, assessed, and treated independently. However, recently researchers, clinicians, and educators have become increasingly concerned that children who have poor reading may be at risk for anxiety (Carroll et al., 2005; Nelson et al., 2015; Nelson & Gregg, 2012; Willcutt et al., 2013). This concern is supported by a recent systematic review and meta-analysis that found a statistically significant and moderate association between poor reading and anxiety ($d = 0.41$; Francis et al., 2019). This same review attempted to determine if poor reading was associated with specific types of anxiety but was unable to do so given the lack of studies investigating poor reading different types of anxiety. Thus, the aim of the current study is to explore if certain types of reading are associated with certain types of anxiety.

Existing studies provide limited information about the specific associations between certain types of reading and certain types of anxiety because many have indexed anxiety using general or “total” scores (i.e., general anxiety). For example, Macdonald et al. (2021) assessed 272 children in Grades 4 and 5 with poor comprehension for three types of reading (word reading accuracy, passage reading fluency, passage reading comprehension) and two types of anxiety (reading anxiety and general anxiety). The results showed a significant association between multiple types of reading (word reading accuracy, passage reading fluency, passage reading comprehension) and reading anxiety, and between passage reading fluency and general anxiety. However, these findings obscure the potential associations between reading and the different types of anxiety (social, separation, or generalized anxiety) that are included in the general anxiety score. Nor do they address any potential associations between reading and panic or obsessive-compulsive symptoms.

On the other hand, some studies comprehensively assess anxiety but fail to capture a broad range of reading problems. For example, Carroll et al. (2005) analyzed a large database of 289 9- to 15-year-old children with reading and spelling difficulties for different anxiety disorders. They found statistically significant associations between poor reading and generalized anxiety and separation anxiety, but not between poor reading and social anxiety, phobias, panic, or obsessive-compulsive disorder. However, this study does not shed light on the associations with certain types of poor reading.

Fortunately, a series of studies by Grills-Taquechel et al., 2012; Grills-Taquechel et al., 2013; Grills et al., 2014) assessed both a range of reading problems (e.g., reading accuracy, reading fluency, reading

comprehension) and anxiety symptoms (e.g., separation anxiety, social anxiety, physical symptoms, harm avoidance) in children. In their 2012 study, they identified 281 Grade 1 children as “typical” ($N = 35$) or “at risk” ($N = 87$) readers using tests of word and nonword reading accuracy and passage reading fluency (Grills-Taquechel et al., 2012). Children were assessed at the beginning, middle, and end of Grade 1 on tests of reading and a self-report anxiety questionnaire. Using hierarchical linear regression, they found that mid-year reading fluency positively predicted separation anxiety at the end of the year (i.e., poor reading fluency predicted greater separation anxiety).

In 2013, Grills-Taquechel and colleagues examined associations between academic performance, anxiety, and inattention concurrently and longitudinally in a subset of 281 Grade 1 children participating in a larger randomized controlled trial (Denton et al., 2011). At the beginning of Grade 1, “at risk” children ($N = 161$) were administered small group reading intervention, and completed tests of reading (basic reading, passage comprehension, word and nonword reading fluency) and self-report anxiety (social anxiety, separation anxiety), as well as mathematics (not reported here) and teacher reported attention at mid and end-of-year. Hierarchical linear regression showed that at the end of year assessment, separation anxiety specifically predicted reading fluency and basic reading scores. Comparisons between the mid-to-end of year assessments showed that greater separation anxiety was associated with decreased fluency for those with good attention, and increased fluency for those with poor attention. Furthermore, mid-year attention was not a significant mediator of the mid-to-end of year anxiety-achievement association.

In their third study, Grills et al. (2014) examined whether anxiety impacted response to reading intervention in 114 Grade 1 children who participated in the same trial noted above. At-risk readers were identified as having poor oral reading fluency, or poor word and nonword reading accuracy or fluency. They completed tests of reading and anxiety at the beginning of the year (autumn), and during winter and spring. In spring, after 4 months of small group reading intervention, children whose reading had improved were classified as “responders” ($N = 33$), while those with ongoing poor reading fluency ($N = 30$) or poor reading fluency and poor decoding ($N = 20$) were classified as non-responders. Repeated-measures ANOVAs that compared non-responders to typical readers ($N = 33$) revealed a reduction in anxiety from winter to spring. Responders showed greater improvements in reading fluency than typical readers, and a reduction in social and separation anxiety. These outcomes support the idea that poor reading—particularly reading fluency—may be reliably related to certain types of anxiety—namely, separation anxiety and generalized anxiety (Carroll et al., 2005; Grills-Taquechel et al., 2012, 2013), and further suggest that social anxiety may be involved in this association (though cf. Carroll et al., 2005).

The results of Grills and colleagues support the idea that certain types of poor reading may be associated with certain types of anxiety. However, these studies focused on children in Grade 1. To date, just one study has comprehensively assessed different types of reading and anxiety problems in older children. Francis et al. (2021a) examined the efficacy of an integrated reading and anxiety intervention in a case

intervention series of seven children aged 7–12 years. The children had multiple reading problems (nonword and word reading accuracy and fluency, text reading accuracy and fluency, and/or passage reading comprehension) and anxiety symptoms and disorders (social anxiety, generalized anxiety, separation anxiety, physical injury fears/phobias). As a group, the children made statistically significant gains in their word and nonword reading accuracy across the intervention period, but not in their reading fluency or comprehension. They also showed statistically significant reductions in their generalized, social, separation anxiety, and panic/agoraphobia symptoms but not their physical injury fears or obsessive–compulsive symptoms. Like previous studies, the results support an association between poor reading and separation anxiety (Grills et al., 2014; Grills-Taquechel et al., 2012, 2013), general or generalized anxiety (Carroll et al., 2005; Macdonald et al., 2021), and social anxiety (Grills et al., 2014), as well as the possibility that these types of anxiety may be related to certain types of reading—specifically, word and nonword reading accuracy. However, the generalizability of these findings is limited due to the small sample included in the case intervention study.

1.2 | The current study

In sum, a handful of studies have examined associations between different types of poor reading and different types of anxiety in children who are English speaking poor readers. To date, the results of these studies suggest that poor reading may be associated with certain types of anxiety in children (generalized, separation, social), and perhaps certain types of poor reading (word and nonword reading accuracy, reading fluency) may be related to certain types of anxiety. However, our understanding of this pattern of findings is limited to six studies investigating these associations. The reliability and/or validity of these studies may be influenced by the fact that some studies recruited larger samples of children (e.g., Macdonald et al., 2021) than others (e.g., Francis, et al., 2021); or assessed a wider range of reading problems (Francis et al., 2021a; Macdonald et al., 2021) than others (Grills-Taquechel et al., 2012). There is also the issue of the potential moderating influence of attention, which was found by Grills-Taquechel et al. (2013) to reverse the relationship between reading fluency and separation anxiety. However, in a recent series of large longitudinal analyses, we found that attention—and its close correlate, behavior (Angold et al., 1999)—did not moderate the association between reading and emotional health in this way (McArthur et al., 2021). Thus, the influence (or not) of attention and behavior on the association between poor reading and anxiety requires further examination.

With all these issues in mind, the aim of this study was to explore if certain types of reading are associated with certain types of anxiety by administering comprehensive assessments of reading (word, nonword, and text reading accuracy, word, nonword, and text reading fluency, passage reading comprehension) and anxiety (social anxiety, generalized anxiety, separation anxiety, physical injury fears/phobias,

TABLE 1 Sample size (*N*), mean (*M*) and standard deviation (*SD*) for reading, anxiety, attention, and behavior scores

		<i>N</i>	<i>M</i>	<i>SD</i>
Accuracy	Nonword reading	284	22.8	21.9
	Irregular word reading	284	27.4	27.2
	Text reading	189	20.1	16.8
Fluency	Nonword reading	282	29.5	27.1
	Word reading	282	24.5	23.7
	Text reading	181	23.9	22.2
Passage reading comprehension		280	28.9	27.0
Social anxiety		284	53.9	8.9
Generalized anxiety		284	53.5	9.1
Separation anxiety		284	52.2	8.5
Physical injury fears		284	51.0	8.1
Panic		284	54.4	6.2
Obsessive compulsive symptoms		284	54.0	6.0
Attention		277	0.0	1.0
Hyperactivity		277	0.0	1.0
Behavior		277	0.0	1.0

panic, obsessive compulsive symptoms) to a large sample of children ($N = 284$) that included a large number of poor readers ($N = 190$). To minimize the chance of adding unreliable outcomes to the existing findings, we conducted four increasingly rigorous analyses (bivariate correlations, partial correlations, principal components analysis, and hierarchical clustering) to examine the relationships between different types of reading and anxiety while controlling, and not controlling, for attention and behavior. To be considered reliable, a relationship was required to hold statistical significance in all four analyses.

Based on existing evidence on poor reading and anxiety in children, we predicted that the bivariate and partial correlation analyses would result in statistically significant negative relationships between (1) reading accuracy (word and nonword) and generalized, social, and separation anxiety, and (2) reading fluency (word and nonword) and generalized, social, and separation anxiety. A second objective of this study was to determine if any reliable associations identified above, were replicated through principal components and hierarchical clustering analyses. Specifically, we expected any specific relationships between type of reading (accuracy or fluency) and type of anxiety (social, separation, generalized) to define groups of children in these fine-grained analyses. We did not make any predictions about the influence of attention and behavior on these relationships due to the lack of existing evidence.

2 | METHOD

The methods for this study were approved by the Macquarie University Human Research Ethics Committee (Reference: 5201500286).

2.1 | Participants

Data was collected from two samples of children. One was a community sample whose parents volunteered them for this study. The second sample included children who were clients of the Macquarie University Reading Clinic. Parents of the former provided informed parental consent, children provided informed verbal assent, and families were reimbursed \$30 for their time. Parents of the latter provided parental consent for their child's assessment data to be used for research purposes.

Children in the community sample were screened for inclusion if parents reported that their child (1) had a history of reading difficulty, (2) had anxiety concerns, (3) spoke English as their primary language at home and school; and (4) did not present with any neurological or sensory problems. Screening tests identified seven children with poor reading alone (i.e., a z -score ≤ -1 on either the nonword or irregular word subtests of the Castles and Coltheart Second Edition; CC2; Castles et al., 2009), 19 children with anxiety alone (i.e., a T -score ≥ 60 on one or more subscales of the Spence Children's Anxiety Scale-Parent report SCAS-P; Spence, 1998), 40 children with poor reading and anxiety, and 25 without poor reading or anxiety. Using the same criteria, the clinic sample included 75 children with poor reading, 30 with anxiety, 68 with poor reading and anxiety, and 20 with neither poor reading nor anxiety.

The combined sample included 284 children with poor reading ($N = 82$), with anxiety ($N = 49$), with poor reading and anxiety ($N = 108$), or without poor reading and anxiety ($N = 45$; see Table 1 for sample size, mean, and standard deviation for reading, anxiety, attention, and behavior scores). Children were aged between 7 and 12 years ($M_{\text{age}} = 9.30$, $SD_{\text{age}} = 1.31$) and were in Grades 2–6 at primary school ($M_{\text{grade}} = 4.06$, $SD_{\text{grade}} = 1.32$). Almost half of the children identified as female (46.9%). Unfortunately, all other demographic and socioeconomic status details are restricted to the community sample (94 of 284 children), which was gathered from the intake questionnaire completed by parents. Most parents reported a university education (65.95%), with other levels of education including 10–11 years (4.25%), 12 years (4.25%), and skilled trade (25.53%). Parents level of employment status varied from part-time (53.19%), full-time (23.40%), casual (14.89%) and unemployed (8.50%). Approximately 75% of families reported a gross household income greater than \$70,000, with others reporting \$25,000–\$45,000 (4.25%), \$45,000–\$70,000 (17.02%), or chose not to report (4.25%). Majority of the sample identified their ethnicity as Caucasian (92%).

2.2 | Measures

Children from the community sample completed an outcome assessment (see Measures section below) in a 1-h in-person session with the first author. The clinic sample completed the outcome measures as part of a lengthier reading, spelling, and language assessment. All

children completed the assessments in a quiet room at Macquarie University.

2.3 | Reading accuracy

2.3.1 | Nonword and irregular words

We used the pencil and paper version of the CC2 (Castles et al., 2009) to measure nonword and irregular word reading accuracy. The CC2 comprises three lists of stimuli: (1) 40 regular words that can be read accurately using phonological recoding alone (e.g., marsh); (2) 40 nonsense words (nonwords) that can accurately be read via phonological recoding alone (e.g., gop); and (3) 40 irregular words that cannot be read accurately using phonological recoding alone (e.g., yacht). Items are presented in intermixed order of increasing difficulty. Testing continues until all three lists have been discontinued (i.e., five consecutive errors), or all items have been administered. Scores are reported as percentiles. The CC2 has good internal consistency ($\alpha = 0.86$ – 0.94 ; Moore et al., 2012) and good test–retest reliability based on an 8-week no training period for the irregular ($r = 0.94$) and nonword ($r = 0.80$) reading lists.

2.3.2 | Text reading accuracy

The Neale Analysis of Reading Ability-3rd Edition (NARA; Neale, 1999) measures both text reading accuracy and comprehension. A child reads aloud up to six text passages that increase in length and complexity. The clinician corrects inaccurate reading. Testing is discontinued when the child makes more than 16 accuracy errors on passages one to four, or more than 20 accuracy errors on passages five or six. In such cases, the comprehension questions are not administered. The number of words read correctly per passage are tallied and converted into percentile scores. The psychometric properties for the NARA are strong ($\alpha = 0.93$), as is the test–retest estimate over an 8-week retest period ($r = 0.93$; Neale, 1999). The NARA also remains a widely used measure and is also routinely administered in the Macquarie University Reading Clinic.

2.4 | Reading fluency

2.4.1 | Nonwords and words

The Test of Word Reading Efficiency 2 (TOWRE 2; Torgesen et al., 2012) comprises a subtest of 63 nonwords (e.g., pim), and 104 words (e.g., book). Children read the items as quickly and accurately as possible in 45 seconds (s). Testing is discontinued after 45 s, or when the child reaches the end of the list. Items are marked as correct (1) or incorrect (0), tallied, and reported as percentile scores. The test–retest reliability and construct validity data for these subtests are greater than $\alpha = 0.90$ (Torgesen et al., 2012).

2.4.2 | Text

The Woodcock Reading Mastery Tests, Third Edition (WRMT-III; Woodcock, 2011) Oral Reading Fluency test comprises grade-based passage sets. The clinician records how long it takes for the child to read each passage aloud. The test is discontinued when the child reads the passage set for their grade. Scores represent the number of words read correctly per 10 s and are converted into percentile scores. This subtest is also reported to have adequate split-half ($\alpha = 0.95$) and test-retest reliability for children in Grades 3–8 ($r = .82$; Woodcock, 2011).

2.5 | Passage reading comprehension

Participants completed two different tests of reading comprehension depending on how they were recruited: the Test of Everyday Reading Comprehension (TERC, McArthur et al., 2013a) for the community sample and the NARA (Neale, 1999) for the clinic sample. Children answered questions about what they read either in passages of text (NARA) or on 10-picture items (e.g., a shopping list; TERC). Correct responses are tallied and converted into percentile scores. The TERC has good inter-rater reliability ($r = 0.99$; McArthur et al., 2013a), as does the NARA ($\alpha = > 0.93$; Neale, 1999). Critically, the two measures correlate well ($r = 0.76$; Wheldall & McMurtry, 2014), which allows us to combine them into a single scale. This maximizes the power of the dataset and so for each child we calculated their z-score on the relevant test and used those standardized scores as the reading comprehension measure.

2.6 | Anxiety

The Spence Children's Anxiety Scale-Parent questionnaire (SCAS-P; Spence, 1998) comprises 38 items divided into six subscales: generalized anxiety, separation anxiety, social anxiety, panic, physical injury fears/phobias and obsessive-compulsive symptoms. Parents indicate how often their child experiences each symptom (e.g., 0 = never, 1 = sometimes, 2 = often, 3 = always). Scores are calculated by tallying the response ratings (i.e., 0, 1, 2, 3), which are converted into standardized *T* scores ($M = 50$, $SD = 10$). Scores equal to or above 60 are considered “elevated”. The subscales have adequate to good internal consistency ($\alpha = 0.61$ to $\alpha = 0.81$) and discriminant validity (*Wilks lambda* 0.65, $p < .001$; Nauta et al., 2004). The SCAS-P is widely used to reliably detect children with and without anxiety disorders (Reardon et al., 2019) and is also administered as part of routine practice at the Macquarie University Reading Clinic.

2.7 | Attention and hyperactivity

The clinic sample completed the inattention and hyperactivity subscales of the Conners-3 Edition (Conners 3; Conners, 2008). Parents

rated their child's inattention (e.g., does not pay attention to details, is easily distracted) and hyperactivity (e.g., is constantly moving, excitable and impulsive) on a Likert scale (0 = not true at all, 1 = just a little true, 2 = pretty much true, 3 = very much true). The community sample completed the hyperactivity/attention subscale of the SDQ-P (Goodman, 1997)—a popular and widely used measure of internalizing and externalizing problems in young people (Bryant & Guy, 2020). This subscale includes items that measure hyperactivity/impulsivity (e.g., restless, overactive; constantly fidgeting or squirming; thinks things out before acting) as well as inattention (e.g., easily distracted, concentration wanders; sees tasks through to the end). Parents rate their child's attention on a three-point scale (0 = not true, 1 = somewhat true, 2 = certainly true). There is evidence that there is a reliable correlation between the inattentive ($r = 0.62$; Erhart et al., 2008) and hyperactivity ($r = 0.56$; Du et al., 2008) subscales of the Conners 3 and the attention subscale of the SDQ in samples of German and Chinese children, respectively. Thus, we combined the two scales and calculated standardized z-scores. These scores were then combined to produce two variables comprising “attention” and “hyperactivity” for the overall sample.

2.8 | Behavior

The clinic sample completed the defiance/aggression subscale of the Conners-3 (Conners, 2008). Parents rated their child's behavior (e.g., starts fights with others on purpose) on a Likert scale (0 = not true at all, 1 = just a little true, 2 = pretty much true, 3 = very much true). The community sample completed the conduct symptoms subscale of the SDQ-P (Goodman, 1997). Parents indicate to what extent each behavior problem (e.g., often has temper tantrums) applies to their child (e.g., 0 = not true, 1 = somewhat true, 2 = certainly true). Research suggests that there is a significant correlation between these two subscales in a sample of Chinese children ($r = 0.53$; Du et al., 2008). Thus, we combined the two subscales by converting the scores into standardized z-scores and combining the scales into a single variable called “behavior”.

2.9 | Data analysis

Four statistical analyses were selected to examine the data. We first analyzed the data using bivariate correlation analysis to determine the presence of any existing associations between types of reading and types of anxiety. In the second analysis, we conducted partial correlations to examine the presence of any such associations while controlling for the unique contribution of attention and behavior. The subsequent analyses adopted a more data-driven clustering approach to explore other relationships that may not have been uncovered by the correlational analyses. In the third analysis, we conducted a principal component analysis to identify combinations of variables that explained variance in the data. The final analysis involved hierarchical

TABLE 2 Bivariate correlations between types of reading and types of anxiety

		Social anxiety	Separation anxiety	Generalized anxiety	Panic	Obsessive compulsive fears	Physical injury fears
Accuracy	Nonword reading	−0.203*	−0.115	−0.143	−0.028	−0.021	−0.067
	Irregular word	−0.190	−0.098	−0.097	−0.01	0.009	−0.096
	Text reading	0.051	−0.02	0.034	0.054	0.034	−0.036
Fluency	Nonword reading	−0.13	−0.118	0.038	−0.018	0.002	−0.078
	Word reading	−0.169	−0.094	−0.111	−0.057	−0.026	−0.089
	Text reading	0.069	−0.081	0.038	0.071	0.039	−0.004
Passage reading comprehension		−0.129	−0.080	−0.058	0.041	0.037	−0.015

Note: * $p < .1/81$ following Bonferroni correction for 81 multiple comparisons (one-tailed)—note only 42 comparisons are reported here.

TABLE 3 Partial correlations between types of reading and types of anxiety controlling for attention and behavior

		Social anxiety	Separation anxiety	Generalized anxiety	Panic	Obsessive compulsive fears	Physical injury fears
Accuracy	Nonword reading	−0.20*	−0.12	−0.14	−0.03	−0.02	−0.07
	Irregular word	−0.19*	−0.10	−0.10	−0.01	0.01	−0.10
	Text reading	0.05	−0.02	0.03	0.05	0.03	−0.04
Fluency	Nonword reading	−0.17	−0.09	−0.11	−0.06	−0.03	−0.09
	Word reading	−0.13	−0.12	−0.09	−0.02	0.00	−0.08
	Text reading	0.07	−0.08	0.04	0.07	0.04	0.00
Passage reading comprehension		−0.13	−0.08	−0.06	0.04	0.04	−0.01

Note: * $p < .00238$ following Bonferroni correction for 42 multiple comparisons.

clustering to identify subtleties and similarities amongst the groups of children. For an effect to be considered reliable, evidence for any found effect was required to be replicated in each step of the analysis.

3 | RESULTS

3.1 | Bivariate correlation analysis

The first analysis investigated whether different types of poor reading are associated with different types of anxiety using bivariate correlations (see Table 2). To ensure one-tailed $\alpha < .05$, we adjusted the p -values for 81 one-tailed comparisons (only 42 comparisons are reported here). The results showed a significant and negative correlation between nonword reading accuracy and social anxiety. There were no other clear or statistically significant correlations between any type of reading or any anxiety symptom following Bonferroni correction. Thus, this suggests that there may be a specific association between nonword reading accuracy and social anxiety.

3.2 | Partial correlations controlling for attention and behavior

The second analysis investigated the associations between different types of poor reading and different types of anxiety while first controlling for attention and behavior (see Table 3). Following Bonferroni

correction ($p < .002$) for 42 multiple comparisons, the results showed a significant and negative correlation between nonword reading accuracy and irregular word reading accuracy and social anxiety. There were no other significant associations between type of poor reading and anxiety. Thus, this suggests that the association between nonword reading accuracy and social anxiety may be independent of attention and behavior problems.

3.3 | Principal components analysis

The correlational analyses described above only consider pairwise relationships between different types of poor reading and different types of anxiety. It is possible that the relationships are more nuanced and involve groups of reading skills and/or anxiety (i.e., reading accuracy and social anxiety). To examine the data for such relations we conducted a principal components analysis (PCA) that included all types of poor reading and anxiety to identify components that explain the largest amount of variance in our dataset (rather than a Factor Analysis which looks for factors that contain common variance in the dataset). The PCA revealed two components with eigenvalues over Kaiser's criterion of 1, accounting for 59.7% of total variance (see Table 4). Subsequent components (3 onwards) had eigenvalues less than 1 so that they explained less variance than any single variable would. From the loadings in Table 4, the two important factors represented general reading skill (good versus poor readers; 36.3% of variance) and general levels of anxiety (anxious versus non-anxious

TABLE 4 Summary of principal component analysis and factor loadings for the first five components

Principal component	1	2	3	4	5
Eigenvalues	2.255	1.808	0.899	0.872	0.850
Cumulative variance	0.363	0.597	0.654	0.709	0.760
Loadings					
Nonword reading accuracy	-0.320	0.026	-0.556	0.099	-0.172
Irregular word reading accuracy	-0.339	-0.003	0.355	-0.146	-0.304
Text reading accuracy	-0.383	0.004	-0.018	0.020	0.040
Nonword reading fluency	-0.334	0.028	-0.397	0.263	0.154
Word reading fluency	-0.373	-0.013	0.211	0.089	0.088
Text reading fluency	-0.383	0.004	-0.018	0.020	0.040
Passage reading comprehension	-0.324	0.030	0.216	-0.282	0.249
Social anxiety	-0.026	-0.360	0.137	0.440	0.648
Separation anxiety	0.022	-0.405	-0.265	-0.233	0.045
Generalized anxiety	-0.018	-0.437	-0.015	-0.102	-0.075
Panic	-0.028	-0.393	0.098	0.501	-0.331
Obsessive compulsive symptoms	-0.022	-0.416	0.125	-0.003	-0.420
Physical injury fears	0.024	-0.391	-0.116	-0.534	0.248

Note: Bold values indicate absolute loadings greater than 0.100.

children; 23.3% of variance). There is no suggestion of links between reading skills (i.e., reading accuracy) and types of anxiety (i.e., social anxiety).

3.4 | Hierarchical clustering

Another technique that can be used to detect hidden relationships between variables is hierarchical clustering (see Robidoux & Pritchard, 2014, for a basic introduction to the approach; Everitt et al., 2011, for a more thorough discussion). Hierarchical clustering seeks to cluster children based on the similarity of their scores on all variables simultaneously. The algorithm then iteratively groups them into larger and larger sets of children that are relatively homogenous within a group, but heterogeneous between groups. There are several methods for clustering available. After fitting the data with each of the methods implemented in the `hclust()` function in R (R Core Team, 2021), we settled on the Ward-linkage method to identify groups of children. Ward-linkage minimizes the mean-squared distance within each group and is generally found to create more “spherical” clusters (clusters of similar size) than other methods.

There is no objective or widely accepted method of selecting the correct number of clusters. Here, we used two approaches. First, we used visual inspection of the clustering dendrogram (a visual depiction of how children are grouped), leading us to six clusters (see Figure 1). We then calculated average scores on all the variables for each group to detect clusters that reflected relationships between kinds of reading skill and anxiety. Figure 2 depicts these means by cluster. In all cases, the reading measures, anxiety measures, and attention and behavior tended to be grouped together in each cluster. This suggests there were no relationships between reading skills or types of anxiety, attention, or behavior that would distinguish some children from their

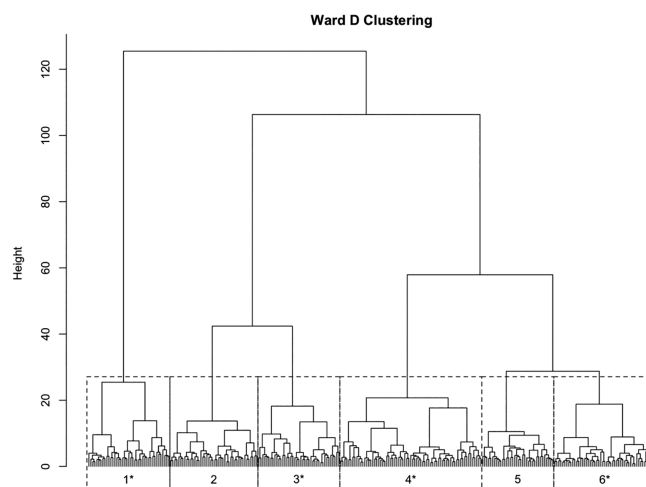


FIGURE 1 Clustering dendrogram using the ward method. The six clusters identified visually are highlighted. Clusters 1, 3, 4, and 6 were subdivided into two for the analysis with 10 clusters.

peers in the sample. In our second approach, we grouped the children into as many clusters as possible while maintaining cluster sizes of at least $N = 15$. This led to 10 clusters. The average score across measures is depicted in Figure 3. Once again, we found that the three categories of measures (reading, anxiety, attention, and behavior) all moved together, failing to uncover any links between reading skills, types of anxiety, or attention or behavior.

4 | DISCUSSION

The aim of this study was to explore if certain types of reading (word, nonword, and text reading accuracy, word, nonword, and text reading

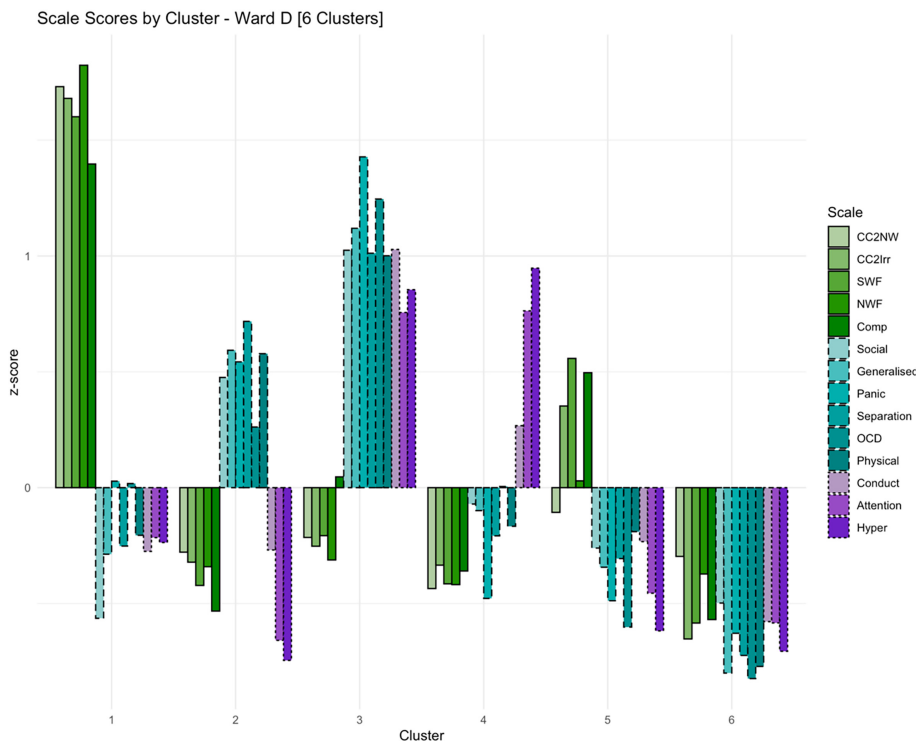


FIGURE 2 Clustering dendrogram using ward-linkage method. The six clusters are identified visually with the mean z-scores for each variable. CC2NW = nonword reading accuracy; CC2Irr = irregular word reading accuracy; SWF = word reading fluency; NWF = nonword reading fluency; Comp = passage reading comprehension; Social = social anxiety; Generalized = generalized anxiety; Panic = panic/agoraphobia; Separation = separation anxiety; OCD = obsessive compulsive symptoms; physical = physical symptoms; conduct = conduct problems; attention = attention symptoms; Hyper = hyperactivity symptoms.

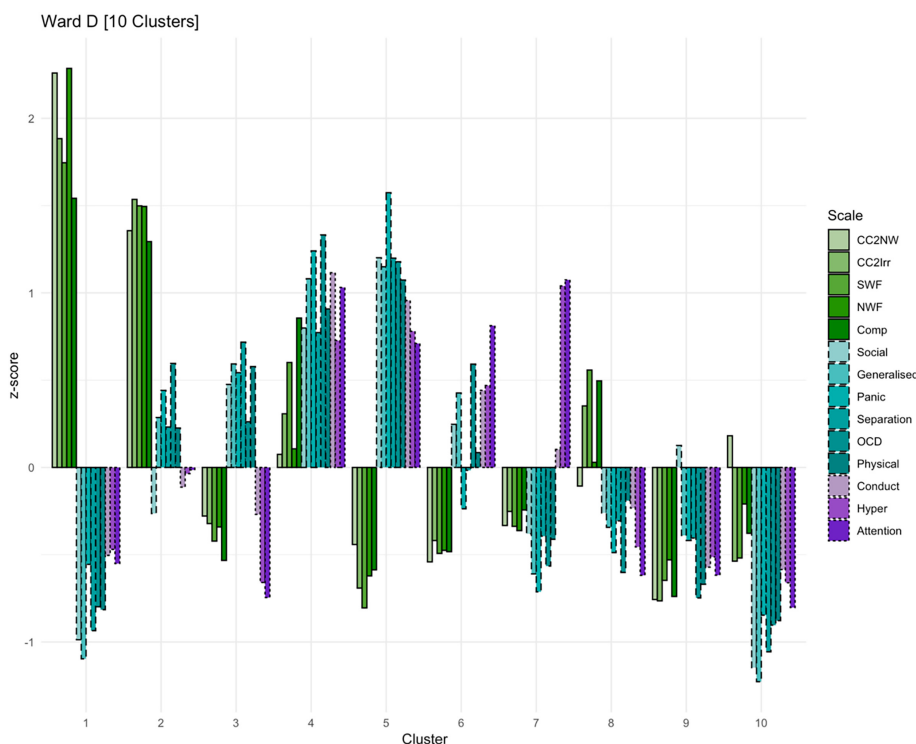


FIGURE 3 Clustering dendrogram using ward-linkage method. The 10 clusters are identified visually with the mean z-scores for each variable. CC2NW = nonword reading accuracy; CC2Irr = irregular word reading accuracy; SWF = word reading fluency; NWF = nonword reading fluency; Comp = passage reading comprehension; Social = social anxiety; Generalized = generalized anxiety; Panic = panic/agoraphobia; Separation = separation anxiety; OCD = obsessive compulsive symptoms; physical = physical symptoms; conduct = conduct problems; attention = attention symptoms; Hyper = hyperactivity symptoms.

fluency, passage reading comprehension) are associated with certain types of anxiety (social anxiety, generalized anxiety, separation anxiety, physical injury fears/phobias, obsessive compulsive symptoms, panic), as well as considering the potential moderating role of poor attention and behavior. We tested 284 children, 82 of whom were poor readers and 108 of whom had poor reading and anxiety. We employed multiple statistical analyses, and only considered an effect to be reliable if it was replicated in each step of the analysis.

4.1 | Associations between type of poor reading and anxiety

Based on the existing evidence, we expected that the bivariate and partial correlation analyses would produce statistically significant negative relationships between (1) reading accuracy (word and nonword) and generalized, social, and separation anxiety, and (2) reading fluency (word and nonword) and generalized, social, and separation anxiety.

There was partial support for this hypothesis. The results showed a significant association between nonword reading accuracy (and perhaps irregular word reading accuracy) and social anxiety, which survived the conservative Bonferroni correction, but no significant association with generalized or separation anxiety. This is consistent with two studies that found an association between poor reading and social anxiety (Francis et al., 2021a; Grills et al., 2014), but contrasts with two other studies that failed to find such an association (Carroll et al., 2005; Grills-Taquechel et al., 2012). However, it is interesting to note that Carroll and colleagues reported a low prevalence of social anxiety in their sample of poor readers (0.31%) and their typical population (1.42%). This is lower than population estimates for social anxiety in children (Lawrence et al., 2015), and may mean that the sample was not representative of the general population. Nonetheless, our current conclusion is that there *might* be a weak association between word and nonword reading accuracy and social anxiety—but more research is needed to inform our understanding.

The bivariate and partial correlations also failed to support an association between types of poor reading and separation anxiety or generalized anxiety. This contrasts with previous studies that have found associations between poor reading and separation anxiety (Grills et al., 2014; Grills-Taquechel et al., 2012, 2013) and general or generalized anxiety (Carroll et al., 2005; Macdonald et al., 2021). One possible explanation for these discrepant findings may relate to the age of participants—particularly for separation anxiety. In their series of studies, Grills and colleagues examined the associations in samples of Grade 1 children. In contrast, the sample included in present study was considerably older ($M_{\text{grade}} = 4.06$, $SD_{\text{grade}} = 1.32$). Thus, it is possible that the association between reading and certain types of anxiety is age dependent. This suggestion is supported by research showing that separation anxiety is more prevalent in younger than older children (irrelevant of reading ability; Lawrence et al., 2015). However, further research is needed to investigate this possibility in children with reading difficulties.

The bivariate and partial correlations also failed to find evidence for a specific association between reading fluency and generalized, social, and separation anxiety. These null findings contradict previous studies that reported associations between reading fluency and separation anxiety (Grills-Taquechel et al., 2012, 2013) and general or generalized anxiety (Carroll et al., 2005; Macdonald et al., 2021). A possible explanation for this discrepancy is that children in the current sample were recruited with poor word and nonword accuracy problems. Despite the co-occurrence of multiple reading problems, it is possible that there were insufficient children in the current sample with specific reading fluency problems to show an effect in the data. It is therefore possible that the recruitment criteria obscured any reliable associations between reading fluency and specific types of anxiety. This should be addressed in future studies by recruiting children with specific reading problems (e.g., poor reading fluency, poor comprehension).

4.2 | Nuanced associations between types of reading and anxiety

Building on our hypotheses, we expected that the association between reading accuracy and social anxiety would define groups of children in the more nuanced principal component and hierarchical clustering analyses. However, neither approach produced this relationship, and there was also no evidence for an association between reading fluency and any type of anxiety problem. One possible reason for failing to replicate our finding in the nuanced analyses is that the type of anxiety associated with poor reading is more specific. The type of anxiety that we are referring to is “reading anxiety”—“a specific, situational phobia toward the act of reading that has physical and cognitive reactions” (see Jalongo & Hirsh, 2010 for discussion). A handful of studies have examined reading anxiety, but only one study has investigated reading anxiety in English speaking children with *poor reading* (Macdonald et al., 2021). Furthermore, while reading-specific anxiety was not directly assessed in this study it is possible that social anxiety related to the *context of reading* is a closely related to reading anxiety. However, the effect for poor readers is too subtle to be captured by the broader construct of social anxiety alone which includes fear of negative evaluation related to reading aloud, as well as situations unrelated to reading (e.g., using the bathroom, talking to others, performances). This highlights a gap in our knowledge and demonstrates the importance of further research to understand how reading anxiety fits into the relationship between type of poor reading and anxiety.

In consideration of our results, we are reluctant to overstate the association between reading accuracy and social anxiety because the effect was not replicated in all four analyses. As mentioned above, the tentative finding also occurs against a background of mixed evidence for (Francis et al., 2021a; Grills et al., 2014) and against (Carroll et al., 2005; Grills-Taquechel et al., 2012, 2013) an association between poor reading and social anxiety, suggesting that this association is one that is either relatively weak or where the contextual influences are not fully understood. There are multiple factors associated with the development and maintenance of anxiety disorders in children (Hudson & Rapee, 2004; Rapee & Spence, 2004). The development of psychopathology is defined by both equifinality and multifinality, meaning that there are multiple pathways to pathological anxiety and each pathway could have multiple outcomes—not only pathological anxiety (Cicchetti & Rogosch, 1996). Reading aloud is a social activity, and it seems likely that children who struggle to read accurately may become embarrassed when they make a reading error. One possibility is that this negative social experience may lead to worry about future negative evaluations (i.e., social anxiety) as well as avoidance of situations in which negative evaluation may occur. This avoidance may then seek to strengthen rather than inhibit this fear memory (Craske et al., 2014). This may be one pathway to social anxiety, but it may also lead to many alternate outcomes in different children. Thus, we need more studies to test this notion and to replicate this finding for a relationship between reading accuracy and social anxiety to be considered reliable.

Alternatively, it is unclear how children with reading difficulties are impacted by their social environment (i.e., peers, classroom environment), and whether their anxiety and fears related to reading are strengthened by watching and learning from other children with these difficulties. One direction for future research could be to apply social learning theory (Bandura, 1977) to better understand the role of the social environment in the development and maintenance of anxiety for children with reading difficulties.

4.3 | Implications

The results from this study have both clinical and theoretical implications. Clinically, our results suggest that children cannot be identified as having a specific poor reading or anxiety profile. This has implications for clinicians, educators, and therapists who work with children. This research highlights the importance of conducting a comprehensive assessment of a child's reading abilities (i.e., reading accuracy, fluency, comprehension) and anxiety symptoms (i.e., social, separation, generalized, obsessive compulsive, panic, physical injury fears/phobias). The tests administered in this study could be useful to guide an assessment battery. The results from any such assessment should then guide a tailored intervention program to support the child.

The clinic sample in the current study highlight the hidden burden of anxiety for many poor readers. The clinic sample were referred for a reading assessment—not for concerns with anxiety. This demonstrates the need for clinicians, educators, and therapists to be aware of the association between poor reading and anxiety and screen for anxiety problems when children are referred for a reading assessment.

While not directly assessed in the current study, the co-occurrence of reading difficulties and anxiety for many children highlight the need to consider how this presentation may impact progress in reading intervention. Anecdotally, parents reported that children with poor reading and anxiety struggled to make gains in reading due to their excessive anxiety. One possible and speculative explanation for this may be that *anxiety is a barrier to a child making progress in their reading intervention*. If this were true, it would provide a key to unlocking access to reading for these children. However, further research is needed to better understand the association between reading and anxiety to optimize intervention outcomes for children.

The current study also adds to the handful of previous studies that have investigated specific associations between types of poor reading and types of anxiety in children. Considered alongside the current results, there appear to be associations between some kinds of reading and social anxiety, however we need more studies on the association between type of poor reading and anxiety to inform a theoretical model about *why* poor reading and anxiety share a relationship. Recent evidence suggests that poor reading is associated with later emotional health problems, rather than vice-versa (McArthur et al., 2021). However, well-controlled studies with children diagnosed with very specific reading and anxiety problems are needed to understand whether there are indeed specific associations between these types of problems and to identify causal mechanisms for theory building.

4.4 | Limitations and future directions

The current study included a large sample of children with a sizeable proportion of poor readers to investigate the association between different types of poor reading and anxiety. We also used the most comprehensive assessment of reading and anxiety in a single sample of children. However, the outcomes of this study must be considered within the context of its strengths and limitations.

First, anxiety, attention, and behavior were measured using parent report questionnaires. Although this informant type is a reliable method of capturing symptoms in children (Nauta et al., 2004), typically a multi-informant approach is recommended. Further, we did not measure anxiety, attention, or behavior symptoms in the classroom setting—where anxiety symptoms arguably may be most prevalent for children with reading difficulties. In addition to classroom variables, factors such as parenting (i.e., parental control; Asbrand et al., 2017), and social stress and motivation (Richey et al., 2019) may provide further insight to potential associations between reading and anxiety. Thus, future studies should consider school (i.e., class environment), home (i.e., parenting style), and personal (i.e., social stress, motivation) factors and evaluate if they mediate any associations between poor reading and anxiety.

Another limitation to consider is the fact that we used one questionnaire to measure anxiety symptoms (i.e., SCAS-P; Spence, 1998). The SCAS-P is a reliable and valid measure of childhood anxiety but does not determine clinical diagnostic status and does not capture the impact of anxiety on a child's life. To further enhance our understanding, a diagnostic interview would provide insight to the association between poor reading and clinical levels of anxiety.

This was the first study to conduct comprehensive assessments of reading and anxiety in older children (i.e., >Grade 1). Even so, we did not capture or assess all types of poor reading or anxiety symptoms that may impact a child. A relevant type of anxiety not assessed is reading anxiety. Reading anxiety may be crucial in understanding the association between poor reading and anxiety, which prompted our development of a reading anxiety questionnaire (Macquarie Oxford Reading Anxiety Test-Child/Parent; MoRAT-C/P; Francis et al., 2021b). We aim to evaluate the association between reading and reading anxiety in future studies.

The final consideration relates to our statistical analyses, which were plentiful and comprehensive. This approach increases the problem of multiple testing and accounted for this by using conservative Bonferroni corrections. Such a conservative approach would have a significant impact on our power to detect effects if they were present in the data. Indeed, most correlations stronger than -0.1 would have been significant without correction. However, the fact that we failed to find a significant effect consistently in multiple analyses highlights the importance of analyzing the data in numerous ways to detect reliable effects. Furthermore, the data strengthens our conclusion that there does not appear to be any consistent or significant associations between any specific type of poor reading and anxiety (i.e., social, generalized and separation) in the current sample. However, it remains important that future studies should be guided by these

outcomes to address the limitations of this study and test more specific hypotheses in a more homogenous sample of children with specific reading difficulties.

4.5 | Summary

This study aimed to understand the association between different types of poor reading (word, nonword, and text reading accuracy, word, nonword, and text reading fluency, passage reading comprehension) and different types of anxiety (social anxiety, separation anxiety, generalized anxiety, physical injury fears/phobias, obsessive-compulsive symptoms, panic). We found partial evidence for our first hypothesis, which indicated a tentative association between word and nonword reading accuracy and social anxiety. However, this finding should be interpreted with caution as this effect did not replicate across analyses. Nonetheless, this research highlights that many children with reading difficulties also experience anxiety, but further research is needed to better understand these nuanced relationships particularly in relation to reading anxiety.

ACKNOWLEDGMENTS

Thanks to the Macquarie University Reading Clinic and associate professor Saskia Kohonen and Dr. Erin Banales for their support of this research. Open access publishing facilitated by Macquarie University, as part of the Wiley - Macquarie University agreement via the Council of Australian University Librarians. [Correction added on 5 July 2022, after first online publication: CAUL funding statement has been added.]

FUNDING INFORMATION

This research was supported by ARC DP200102241.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data are not publicly available due to privacy or ethical restrictions.

ORCID

Deanna A. Francis  <https://orcid.org/0000-0001-9962-3934>

Serje Robidoux  <https://orcid.org/0000-0002-4581-3297>

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How to cite this article: Francis, D. A., Hudson, J. L., Robidoux, S., & McArthur, G. M. (2022). Are different reading problems associated with different anxiety types? *Applied Cognitive Psychology*, 36(4), 793–804. <https://doi.org/10.1002/acp.3970>