Tracing the longitudinal role of orthographic knowledge in spelling development from primary to upper-secondary school

Jakob Åsberg Johnels
Institute of Neuroscience and Physiology, University of Gothenburg, Gothenburg, Sweden

Christian Waldmann
Department of Swedish, Linnaeus University, Växjö, Sweden

Maria Levlin
Department of Language Studies, Umeå University, Umeå, Sweden

Background: Phonological processing skills have been found to contribute to spelling development across different orthographies; however, less is known about the role of orthographic knowledge. This longitudinal study explores the contribution of phonological and orthographic knowledge to spelling development in a semi-transparent orthography (Swedish) across a period of 10 years.

Methods: A group of Swedish speaking children were assessed on phonological recoding (phonological choice-task), orthographic knowledge (choice-task) and spelling (dictation task) in primary school (grade 2, age 8, total N = 99), secondary school (grade 8, age 14, N = 99) and again in upper secondary school (year 2, age 17, N = 79). Furthermore, spelling in a natural writing assignment was collected in upper secondary school. Spelling scores from grade 8 (dictation) and year 2 in upper secondary school (dictation and text) were included as dependent variables in three sets of hierarchical regression analyses. In the first step spelling performance in grade 2 was included to control for the autoregressive effect. In the second step, orthographic knowledge and phonological recoding from grade 2 were entered into the model in order to test for the longitudinal prediction.

Results: Test scores within and across ages were significantly correlated in bivariate analysis. Regression analysis revealed that orthographic knowledge in grade 2 was a unique longitudinal predictor of spelling performance across time-points (secondary and upper secondary school) and assessment formats (dictation and text), beyond the contribution of the control variables.

Conclusions: This study confirms the role of early orthographic knowledge in Swedish spelling development throughout the school years assessed in standardized dictation tasks as well as in naturalistic writing assignments.

Keywords: spelling development, orthographic knowledge, phonological recoding, longitudinal study
Highlights

What is already known about this topic

- Being able to spell well is important because it opens up the ability to communicate clearly in writing.
- Less is known about predictors of spelling development than of reading development.

What this paper adds

- This study explores the role of orthographic lexical knowledge and phonological recoding as predictors of spelling development in Swedish, which has a semi-transparent orthography.
- The study adds important knowledge to the field as it contains a long term follow up over a period of almost 10 years.
- Results show that lexical orthographic knowledge is an important longitudinal predictor of spelling development, according to both dictation and naturalistic text writing outcomes.

Implications for theory, policy or practice

- The results have theoretical implications for understanding orthographic knowledge, and its relation to phonological processing and spelling development.
- The results show that already in second grade, children vary in their orthographic lexical knowledge.
- More research is needed in order to understand why these early differences emerged, and how to best support those falling behind in practical settings.

For some lay people and even educators, spelling and spelling development is considered a dull and mechanistic aspect of human language – and that attending to and ‘nit-picking’ about children’s spelling accuracy hinders rather than supports their writing development (cf., Amtmann et al., 2008, for a discussion). What research has suggested, however, is that spelling is far from a mechanistic skill, but instead a complex psycholinguistic one that draws on different kinds of knowledge (Kemp & Treiman, 2022; Perfetti & Hart, 2002).

Also, fluent spelling is important for reducing working memory load and making cognitive resources available for higher-level writing processes such as text production and organization – that is, being able to spell well opens up the ability to communicate clearly in writing (Alves & Limpo, 2015; Connelly et al., 2012). Indeed, spelling difficulties have been found to impact written text quality in students with dyslexia (Berninger et al., 2008; Sumner et al., 2016) and to persist over time (Eklund et al., 2015; Maughan et al., 2009). Still,
the kinds of knowledge underlying spelling and spelling development has received less attention in research than what is the case for reading, limiting both theoretical development and practical understandings of how to best support developing spellers (Bahr et al., 2020). The current study explores the longitudinal contribution of phonological and orthographic knowledge to spelling development by following a group of students with Swedish as their first language from primary school all the way up to upper secondary school.

As a child initially attempts to spell words, a sounding out strategy is commonly employed. Phonemic awareness, that is, the ability to segment words into constituent phonemes, is an important component of phonological knowledge and has been shown to predict spelling development in a large body of research including opaque, semi-transparent and transparent orthographies (Furnes & Samuelsson, 2011; Landerl & Wimmer, 2008; Shahar-Yames & Share, 2008; Torppa et al., 2017). Indeed, supporting phonological awareness in pre-schoolers at risk for dyslexia has been shown to positively affect the development of spelling skills several years later (e.g., Wolff & Gustafsson, 2022). As an umbrella term, phonological processing is often used to include implicit processes such as phonological short-term memory and access to stored phonological information, for example in rapid automatic naming tasks (Melby-Lervåg et al., 2012). Moreover, phonological recoding – that is, connecting phonemes and graphemes for the purpose of encoding or decoding words – has in itself been suggested as a phonological skill with a particularly proximate relation to spelling (and to reading), and has been shown to mediate the association between phonological short-term memory and spelling performance (Åsberg Johnels et al., 2014). Phonological recoding is often measured by decoding nonwords or – as is done in the current study – by phonological choice tasks (Hagiliassis et al., 2006) in which a person is asked to decide which of a selection of written nonwords that sound like a real word if sounded out, for example, ‘gaim’ versus ‘roaf’.

Orthographic processing, by contrast, refers to knowledge about various spelling patterns that characterize specific words or word parts. This type of knowledge includes the orthographic learning that has developed through exposure to print and statistical learning of sound-spelling patterns (Cunningham et al., 2001; Nation & Castles, 2017; Treiman, 2018). Indeed, when a child develops as a speller s/he will soon encounter spelling tasks that are hard to master through the sole reliance on phonological knowledge – such as the distinction between ‘their’ and ‘there’ or how to spell irregular words such as ‘yacht’. In ordinary reading and spelling tasks, phonological and orthographic knowledge are highly intertwined (Hagiliassis et al., 2006; Nation & Castles, 2017), but attempts have been made to tease these aspects apart for assessment purposes. In particular, in the orthographic choice task a person is asked to select which of two written homophone words that is correctly spelled, for example, ‘taksi’ versus ‘taxi’. Other kinds of orthographic tasks have also been developed and while they seem to psychometrically form a unitary construct (Cunningham et al., 2001), in some research a distinction is made between word specific and general orthographic knowledge, with general knowledge including knowledge about the consistencies and conventions for different grapheme combinations in a specific language (e.g., Conrad et al., 2013).

It has been questioned whether phonological and orthographic knowledge should be best viewed as separate constructs or not – and, in particular, whether orthographic knowledge represents a unique kind of knowledge with implications for reading and spelling development or if it is completely parasitic on phonological skills (e.g., Burt, 2006; Conrad et al., 2013; Hagiliassis et al., 2006; Rakhlin et al., 2019). In support of the former position, Share (1995) suggests that by using phonological recoding in reading and spelling, the
reader/writer will learn and consolidate word-specific and general orthographic knowledge through a self-teaching mechanism; that is, according to this account orthographic knowledge develops as a by-product (rather than a predictor) of decoding and spelling development (Shahar-Yames & Share, 2008; Share, 1995). Later developments of this theory showed that phonological encoding during early spelling activities, in particular, had consequences for orthographic learning; for instance, Shahar-Yames and Share (2008) found a spelling intervention to be more effective for orthographic learning than a reading intervention, with one proposed reason being that spelling requires an active retrieval of detailed orthographic knowledge of sound-spelling relationships letter-by-letter, while decoding ‘only’ requires recognition of spelling-sound patterns.

By contrast, several research studies utilizing regression analytical approaches to parse variance in spelling ability have reported that orthographic task performance accounts for unique variance in spelling even when placed alongside other relevant independent variables, including phonological skills. For instance, in a small-scale cross-sectional study by Conrad et al. (2013), with participants aged 7 to 9 years, word-specific and general orthographic knowledge were found to contribute uniquely to reading and spelling even when controlling for phonological skills. Similarly, McGeown et al. (2014) explored the role of reading frequency, vocabulary, phonological and orthographic knowledge when reading and spelling irregular words in 180 primary school students. Phonological (decoding non-words) and orthographic (orthographic choice test) knowledge contributed equally to the spelling performance, over and above the variance explained by vocabulary and reading frequency.

Most previous studies have been conducted in English-speaking contexts, and because English has been considered an ‘outlier’ in terms of orthographic complexity, it is important to also consider possible cross-linguistic differences (Share, 2008). For example students learn to read (Seymour et al., 2003) and spell (Treimann et al., 2023) more quickly in shallow (e.g., Finnish and Italian) than in deep (e.g., English and French) orthographies. Further, orthographic complexity seems to have a moderating effect on the relation between phonological processing skills and reading/spelling development (Candan et al., 2020; Furnes & Samuelsson, 2011; Landerl & Wimmer, 2008). For example, letter knowledge and phonemic awareness have been found to significantly predict spelling development in both English and more transparent orthographies; however in transparent orthographies the influence of these predictors tend to diminish after the initial learning phase (see overview in Caravolas, 2004).

Some previous studies, though, have been conducted in other language contexts than English. For example, Rothe et al. (2015) explored phonological processing and orthographic knowledge in relation to spelling among primary school students with reading difficulties and typical reading in a semi-transparent orthography, namely German. Here, again, the orthographic tasks explained an additional, sizable share of the variance (12% and 9%, respectively), over and above the influence of phonological processing skills (phonological awareness, RAN, phonological short-term memory). In a more recent, small-scale study conducted in primary schools in Germany, Zarić et al. (2021) confirmed that orthographic knowledge plays a role in spelling; word-specific and general orthographic knowledge were found to explain 31% of the variance in spelling, with word-specific (e.g., orthographic choice performance) being the main contributor.

Thus, there appears to be a role for orthographic knowledge in spelling performance according to several published cross-sectional studies. As with any cross-sectional study, however, it is challenging to determine the developmental dynamics and direction of
causality involved in these observed associations – and, in particular, to what extent spelling and phonological development is shaped by orthographic knowledge, rather than vice versa. A seminal study by Deacon et al. (2012) addressed this ‘chicken-egg’-problem in the context of reading development by longitudinally predicting word reading development from earlier measured orthographic knowledge, in an analysis in which earlier reading performance was statistically controlled (the autoregressive effect). In this study, the results showed that children seemed to acquire orthographic knowledge through their reading, in keeping with the self-teaching account (Share, 1995), rather than vice versa, and, more generally, that orthographic knowledge ‘does not play an independent role in supporting reading acquisition’ (p. 110). A similar conclusion was obtained in a longitudinal study of both word reading and spelling development in French-English bilinguals (Chung et al., 2022). However, again, there might possibly be important cross-orthographic differences to consider (French and English both have opaque orthographies). Another recent study by Querido et al. (2021) longitudinally followed children from grade 2 to 5 who were learning to spell in Portuguese, which is a semi-transparent orthography. Here, orthographic lexical knowledge was indeed found to longitudinally predict different tests of spelling performance at several time points, and, moreover, orthographic knowledge predicted spelling more consistently and earlier than reading. However, this study also had its limitations as the autoregressive effects of earlier spelling performance did not seem to be statistically controlled.

In sum, more longitudinal studies are needed for a better understanding of the possible role of orthographic factors in spelling development, and across different orthographies. To the best of our knowledge, very few studies have explored the role of early phonological and orthographic knowledge in spelling development longitudinally, and no prior research has had a long term follow up period from primary to upper secondary school. In the current study, therefore, we explored the contribution of early phonological recoding and orthographic knowledge in primary school to spelling longitudinally in primary, secondary and upper secondary school in Swedish, which has a semi-transparent orthography. Further extending previous studies, we not only utilize dictation to assess spelling performance but also explore to what extent early phonological recoding and orthographic knowledge contribute to spelling performance in naturalistic written text production in later school years. This was done in order to better probe the educational relevance of any suggested association between early orthographic knowledge and spelling development. The following research questions were explored:

- What is the contribution of early spelling skills, phonological recoding and orthographic knowledge in primary school to later spelling development in secondary and upper-secondary education?
- Does the pattern of prediction differ depending on the measure of spelling ability, namely dictation and text writing in upper-secondary education?

Methods

The current study took place in Sweden where compulsory education includes primary school (grade 1 to 6, age 7–12) and secondary school (grade 7–9, age 13–15). After compulsory school a vast majority of students continue to upper-secondary school to pursue
another 3 years of study on a vocational or higher education preparatory program (age 16–18).

Participants
All students \((N = 132)\) attending the only secondary school in a municipality in Sweden were invited to take part in this study at two consecutive occasions, at first in eighth grade in secondary school and secondly in their second year in upper secondary school. In total, 102 students (52 girls, 50 boys) agreed to participate in grade 8, and 79 (35 girls, 39 boys) of these students provided consent at the follow up in upper secondary school. The participants consented for the researchers to gain access to literacy measures that had been previously collected as part of a general screening programme in the municipality in grade 2 in primary school (age 8). Furthermore, participants consented to participate in the literacy assessments conducted in grade 8 in secondary school (age 14) and year 2 in upper secondary school (age 17) as part of the current research project. In upper secondary school, the students attended both vocational \((n = 43)\) and higher education preparatory programmes \((n = 36)\). All students had Swedish as their first language.

Procedure
Informed consents from parents and students were obtained prior to the assessments in secondary school and in upper secondary school. The project followed the ethical guidelines of the Swedish Research Council (Stafström, 2017) and was assessed by the Regional Ethical Review Board as not falling under the Swedish Ethical Review Act (no intervention, no sensitive personal information, no collection of biological material) (dnr 2015/334-331Ö). The board provided a formal statement with recommended amendments that were followed. All assessment tasks were carried out as group assessments in the classroom by the teachers in primary school and by the teachers in collaboration with the research team in secondary and upper secondary school. The administration of the tasks followed the standard procedures in the manuals. The assessments in grade 2 in primary school were part of the schools regular screening routines, while assessments in grade 8 were partly initiated by the researchers (orthographic knowledge and phonological recoding) and partly included in the schools’ regular routines (spelling dictation task). All assessments in upper secondary school were initiated by the researchers. The students were allowed to terminate the researcher-initiated assessments at any time, and information from the teacher-initiated assessments was only collected from those students who had agreed to participate in the research project. Some students did not perform all tasks, hence the total sample size varies somewhat depending on the analysis.

Measures

*Orthographic Knowledge (Olofsson, 1998, modelled after Olson et al., 1985)*

The students read pairs of words silently. In each pair, one word was correctly spelled, and one was a pseudo-homophone of the target word, for example, *taksi-taxi*. Students were asked to mark the correctly spelled word in as many word pairs as possible within 2 min. The score was the total number of correctly marked words (max 140 points). The
same task was used in grade 2, grade 8 and year 2 in upper secondary school. In the manual, adequate psychometric properties are established by showing large correlations with other, related, literacy measures. Moreover, Gustafson et al. (2013) reported a test–retest correlation of $r = .91$ on the task.

**Phonological Recoding (Olofsson, 1998, modelled after Olson et al., 1985)**

The students read triplets of written nonwords silently and were asked to mark the nonword sounding like a real word if sounded out, for example, $vasp – jus – sorf$ where $jus$ is a homophone to $ljus$ ‘light’. The score was the total number of correctly marked homophones identified within 2 min (max 80 points). The same task was used in all three grades. In the manual, moderate and large correlations are reported with other, related, literacy measures. Although test–retest data is not reported in the manual, another, very similar, Swedish phonological choice task for children reported a test–retest correlation of $r = .84$ (Wolff, 2010). Moreover, in the current sample (see Table 1) longitudinal (test–retest) stability was substantial on the task, despite several years passing in-between assessment points (e.g., $r = .74$, between grade 8 and year 2 in upper secondary school). Thus, psychometric properties on the task are assumed to be at the very least adequate.

**Spelling – Dictation (Järpsten, 1999; Järpsten & Taube, 2018; Johansson, 2004)**

In all three grades, the students listened to a story with each sentence containing a target word. The target word was orally repeated by the test administrator and thereafter written by the students. In grade 2, most target words had a regular spelling, word length varied from 3–7 letters, and half of the words included consonant clusters. In grade 8 and year 2 in upper secondary school, most of the target words represented complex word structures in phonology (several consonant clusters in the same word), orthography (irregularities in spelling) and morphology (compound words). The final score was the number of correctly spelled words with a maximum score of 20 points in grade 2, 50 points in grade 8 and 36 points in upper secondary school. According to the manuals, Cronbach’s alpha was 0.73 for grade 2 (Järpsten, 1999), 0.89 for grade 8 (Johansson, 2004) and 0.89 for upper secondary school (Järpsten & Taube, 2018).

**Spelling in Written Text Production in Upper Secondary School**

Students wrote one narrative and one argumentative text in Swedish. Each assignment was given 45 min. Written text quality was examined using Jacobs et al.’s (1981) analytic scoring scheme. A slight adaptation was utilized as we subdivided the mechanics category into spelling and punctuation, which resulted in a total of seven aspects of text quality: content, organization, cohesion, vocabulary, language use, spelling, and punctuation (see Sehlström et al., 2022 for a detailed description). In this study, only spelling was used. Spelling was assessed using a scale from 1 to 4 with the following criteria: (4) demonstrates mastery of conventions, no errors of spelling; (3) occasional errors of spelling, but meaning not obscured, no strain on reader; (2) frequent errors of spelling, strain on reader, meaning confused or obscured; (1) no mastery of conventions, dominated by errors of spelling. The interrater reliability was established through double scoring of 20% of the texts by two independent raters. The intraclass correlation coefficient (ICC) was 0.88 for spelling. A composite measure was used based on the spelling score for both writing assignments (internal validity = 0.75).
Table 1. Descriptive statistics and correlations for orthographic knowledge, phonological recoding and spelling in grade 2, 8 and upper secondary school.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>M</th>
<th>SD</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Orthographic: Grade 2</td>
<td>99</td>
<td>18.30</td>
<td>11.40</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Phon recoding: Grade 2</td>
<td>99</td>
<td>9.87</td>
<td>5.64</td>
<td>0.64**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Spelling: Grade 2 (z)</td>
<td>99</td>
<td>16.01 (0.11)</td>
<td>2.48 (0.85)</td>
<td>0.61**</td>
<td>0.38**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Orthographic: Grade 8 (z)</td>
<td>99</td>
<td>75.05 (−0.44)</td>
<td>17.69 (0.90)</td>
<td>0.53**</td>
<td>0.32*</td>
<td>0.30*</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Phon recoding: Grade 8 (z)</td>
<td>97</td>
<td>26.57 (−0.48)</td>
<td>8.57 (0.80)</td>
<td>0.56**</td>
<td>0.47**</td>
<td>0.40**</td>
<td>0.64**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Spelling: Grade 8 (z)</td>
<td>93</td>
<td>31.43 (−0.35)</td>
<td>8.53 (1.0)</td>
<td>62**</td>
<td>0.47**</td>
<td>0.50**</td>
<td>0.51**</td>
<td>0.55**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Orthographic: Upper sec (z)</td>
<td>78</td>
<td>90.64 (−0.00)</td>
<td>18.21 (0.88)</td>
<td>0.57**</td>
<td>0.39**</td>
<td>0.35*</td>
<td>0.69**</td>
<td>0.62**</td>
<td>0.52**</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8. Phon recoding: Upper sec (z)</td>
<td>78</td>
<td>33.38 (0.17)</td>
<td>9.65 (1.0)</td>
<td>0.55**</td>
<td>0.46**</td>
<td>0.36*</td>
<td>0.51**</td>
<td>0.74**</td>
<td>0.51**</td>
<td>0.66**</td>
<td>-</td>
</tr>
<tr>
<td>9. Spelling: Upper sec (z)</td>
<td>79</td>
<td>27.13 (0.40)</td>
<td>5.82 (0.83)</td>
<td>0.49**</td>
<td>0.37*</td>
<td>0.39**</td>
<td>0.42**</td>
<td>0.38**</td>
<td>0.82**</td>
<td>0.55**</td>
<td>0.48**</td>
</tr>
<tr>
<td>10. Spelling: text Upper secondary</td>
<td>75</td>
<td>2.39</td>
<td>0.79</td>
<td>0.44**</td>
<td>0.31*</td>
<td>0.33*</td>
<td>0.36*</td>
<td>0.39**</td>
<td>0.64**</td>
<td>0.46**</td>
<td>0.47**</td>
</tr>
</tbody>
</table>

* p < .01.
** p < .001.
Analytical Strategy and Statistics

We first report descriptive data and bivariate correlations between all the included variables. In the analyses, we use raw scores but we also report norm-referenced z-scores based on means and standard deviations reported in the test manuals. In order to test the predictive role of early orthographic knowledge and phonological recoding we conducted a set of regression analyses with the spelling scores from grade 8 and year 2 in upper secondary as dependent variables. As predictors, we first included the autoregressor, that is, grade 2 spelling performance. Next, we included the main variables of interest – that is, orthographic knowledge and phonological recoding simultaneously. A two-tailed alpha level of 0.05 was applied.

Results

Means, standard deviations and correlational patterns between measures are reported in Table 1. The relationship between the measures was investigated using Pearson product–moment correlation. There was a medium to strong positive correlation between orthographic knowledge, phonological recoding, and spelling within grade 2, 8 and upper secondary school, respectively, as well as across grades. Thus, in keeping with prior research, individual differences in these skills are associated.

To examine whether orthographic knowledge and/or phonological recoding collected in primary school longitudinally predicted development in spelling performance over the 6 and 9 years follow up period, we next performed three sets of hierarchical regression analyses with the spelling dictation scores from grade 8 and year 2 in upper secondary school as well as the text spelling scores from upper secondary school as the dependent variables. The results are presented in Table 2. In the first step, we included the spelling scores from grade 2 to control for the autoregressive effect. In all age groups, the spelling control variable from grade 2 explained a significant amount of the variance in later spelling scores, confirming the longitudinal stability of individual differences in spelling performance.

<table>
<thead>
<tr>
<th>Table 2. Hierarchical regression analyses.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Step 1</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Spelling dictation Gr 2</td>
</tr>
<tr>
<td>Step 2</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Orthographic knowledge Gr 2</td>
</tr>
<tr>
<td>Phonological recoding Gr 2</td>
</tr>
</tbody>
</table>

Note: Final beta value refers to the beta value in the model with all predictors included.

* $p < .05$.

** $p < .01$.

*** $p < .001$.
Note in Table 2 that the explained variance was somewhat lower for upper secondary spelling scores in the text writing task.

In the second step, we entered the orthographic knowledge and phonological recoding scores from grade 2. A significant additional proportion in spelling variance was explained in all age groups and across assessment formats (all changes in $F$ with $p < .05$). Critically, as detailed in Table 2, only the orthographic scores uniquely predicted spelling development beyond the contribution of the control variables. Thus, our study not only shows a longitudinal stability in individual differences in children’s spelling, and in phonological recoding and orthographic knowledge, but it also suggests that early orthographic knowledge has a special role in predicting individual spelling development across the school years in the study cohort.

**Discussion**

The development of orthographic knowledge and its role in spelling development has been subject to less research than phonological knowledge. The findings in the current longitudinal study, conducted in the semi-transparent Swedish orthography, show that early lexical orthographic knowledge (in primary school) is predictive of the development of spelling skills, and that this pattern is consistent across the studied measurement points (secondary and upper secondary school) and assessment approaches (dictation task and naturalistic writing assignment). Some notable features, including both strengths and potential limitations, of our study need to be discussed.

An important contribution in our study, compared with most prior work, is the long-term longitudinal design. This, in turn, made it possible for us to trace the longitudinal role of 2nd grade orthographic knowledge all the way up to upper secondary school, that is, over a period of 9 years. Statistically, this meant that we could include the autoregressive effect (i.e., the measure of the skill being predicted, in our case spelling, at an earlier time point) in the prediction model. This design is particularly important for its potential in informing causal hypotheses. Several authors have argued that an additional variable predicting the outcome measure after the inclusion of the autoregressive effect can be taken as potential support for a causal association between that variable and the outcome measure (De Jong & van der Leij, 2002; Oakhill & Cain, 2012).

Another noteworthy feature of the study was that, besides spelling dictation, we used a naturalistic writing task in upper secondary school to assess spelling. According to Amtmann et al. (2008), it is important in cognitively oriented writing research to demonstrate that findings transfer to more naturalistic tests, not least because there is a widespread scepticism among some ‘whole language’-educated teachers regarding de-contextualized literacy tests. Also, it is known that some poor spellers tend to avoid certain (hard) words during text generation (Sumner et al., 2016; Wengelin, 2007), meaning that difficulties seen on a cognitive task of phonology or orthography perhaps might not necessarily surface in their naturalistic writing products. Thus, we find it particularly important to note that the findings reported seem robust across different specific assessment formats of spelling.

It is important to note that in our study we focused on a general, population-based sample. Thus, the predictive relations might well differ if only poor spellers had been considered. Speculatively, this might be one reason for why we failed to find a unique predictive role of early phonological recoding in spelling development in our study cohort. Indeed, in
prior research in semi-transparent orthographies, the unique predictive role of phonological skills tends to wane with development among population samples (Candan et al., 2020; Furnes & Samuelsson, 2011). Another plausible reason why we did not find a consistent influence of phonological skills on spelling development could be the choice of the assessment instrument. Phonological processing is a complex construct including explicit (phonological awareness) and implicit (short-term memory, RAN) skills (cf., Katzir et al., 2006). In this study, we used only one phonological task, phonological recoding, and it is, therefore, possible that other or additional phonological measures would have led to a different outcome. Please note, however, that in our study, phonological skills consistently correlated with spelling scores across all measurement points.

Perhaps relatedly, our first assessment point of spelling, orthographic and phonological knowledge was in second grade (meaning approx. 8 years of age), that is, at a time when most children were well beyond cracking the alphabetic code and had developed some proficiency in fluent reading and spelling. This makes our findings a bit complicated to compare with some similar, prior work, such as Deacon et al. (2012) who focused on the first steps in spelling development from grade 1–3, when the role of orthographic versus phonological knowledge in spelling could be different. Indeed, according to several influential models (e.g., Ehri, 2013) in early spelling development, children rely on a phonological, sounding out strategy whereas the role of other knowledge cues (e.g., orthographic or morphological) becomes more prominent with development. Thus, we suspect that had we followed children from preschool age or first grade, the associations might have differed than what was presented here; for example, phonological recoding might have had a stronger predictive role at a younger age.

Our study confirms the role of early orthographic knowledge in predicting Swedish spelling development throughout the school years. Given that orthographic knowledge, by definition, is experience/exposure dependent (Nation & Castles, 2017), it is quite striking that orthographic knowledge already in second grade seems to hold such a powerful predictive role. Thus, the intense research focus that currently is being placed on understanding the mechanisms underlying orthographic knowledge and learning (e.g., Nation & Castles, 2017; Treiman, 2018) seems highly justified based on the findings presented here. Besides the important role of phonological recoding (Share, 1995), a number of additional candidate factors have been proposed as drivers of orthographic processing in recent research, with some empirical support, for example, morphological skills (Pacton et al., 2018), visual attention span (Bosse, ), statistical visual learning (Tong et al., 2019) and paired associate learning (Wang et al., 2017). Also, our research only considered word-specific orthographic knowledge as a predictor of spelling development. As noted in the introduction, some previous research distinguishes between ‘general’ and ‘word-specific’ orthographic knowledge, which might be an analytically important distinction (e.g., Conrad et al., 2013) although some previous studies have indeed shown that these kinds of tasks tend to form a unitary construct (Cunningham et al., 2001). Moreover, as highlighted by Deacon et al. (2019), the concept of orthographic skills might best be subdivided into a more nuanced distinction between a crystalized orthographic knowledge dimension (tapped with tasks such as that adopted in our study) versus a more dynamic orthographic learning dimension in order to better understand mechanisms of orthographic processing and their relations to reading and spelling development more generally. Clearly, more research in the field is warranted in order to identify the mechanisms and methodological boundary conditions to the findings reported in our study.
Even though our study is unique in its population-based, long-term follow-up approach, an important limitation is that our study contains a relatively small sample size. In particular, this had effects on our choice of statistical analysis, meaning that we chose to rely on multiple regression analyses, rather than more complex approaches such as growth curve or structural equation modelling approaches. Considering this, we also refrained from trying to model the more complex reciprocal relations between spelling and orthographic development. Another limitation of our study is the lack of information on certain background factors that potentially might influence the course of orthographic and spelling development. For instance, we do not have individual-level data on family socioeconomic status or on additional cognitive skills (e.g., morphological awareness or IQ) of the child at age 8 years. Future research would benefit by including these and other factors when modelling spelling development.

Despite these caveats, our study does contribute with new evidence that early individual differences in lexical orthographic knowledge predict development of spelling performance, and that this is the case throughout the school years and across assessment formats.

Acknowledgements

This research was supported by the Swedish Research Council (grant number 2018-03729) and a grant from Umeå School of Education. We wish to thank all participating students, teachers and principals for making this study possible. We are also grateful to Pär Sehlström and Annie Sebbfolk for their help with data collection and the analysis of the written texts in upper secondary school.

Data Availability Statement

The data have not been made available on a permanent third-party archive because participants were not asked to consent for their data to be made publicly available, even anonymized, due to constraints in the ethical permission. Data are available upon request from those who wish to collaborate with us, via an external affiliation with the Umeå University, if appropriate, and under the existing ethical vetting.

References


Jakob Åsberg Johnels is an associate professor at the University of Gothenburg, Sweden. His research interests include the development, and developmental disabilities, of language, learning and social skills in children and adolescents.

Christian Waldmann is a professor of Swedish at the Department of Swedish at Linnaeus University in Växjö, Sweden. His research interests include writing, language development, oral language support and grammar.

Maria Levlin is an associate professor at the Department of Language Studies in Umeå, Sweden. Her main research interests are language, reading and writing difficulties.

Received 25 January 2023; revised version received 12 December 2023.

Address for correspondence: Jakob Åsberg Johnels, Institute of Neuroscience and Physiology, University of Gothenburg, Box 455, Gothenburg SE-40530, Sweden. Email: jakob.asberg@gnc.gu.se Maria Levlin, Department of Language Studies, Umeå University, Umeå, Sweden. Email: maria.levlin@umu.se