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Frequency Analyses of Prephonological Spellings as Predictors of Success in Conventional Spelling

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Abstract

The present study explored how children's prephonological writing foretells differential learning outcomes in primary school. The authors asked Portuguese-speaking preschool children in Brazil (mean age 4 year 3 months) to spell 12 words. Monte Carlo tests were used to identify the 31 children whose writing was not based on spellings or sounds of the target words. Two and a half years later, the children took a standardized spelling test. The more closely the digram (two-letter sequence) frequencies in the preschool task correlated with those in children's books, the better scores the children had in primary school, and the more preschoolers used letters from their own name, the lower their subsequent scores. Thus, preschoolers whose prephonological writing revealed attentiveness to the statistical properties of text subsequently performed better in conventional spelling. These analytic techniques may help in the early identification of children at risk for spelling difficulties.

Keywords

spelling, dyslexia, precursors, preschool, longitudinal

Much work has been devoted to identifying factors that can help educators identify children at risk of poor or delayed acquisition of literacy skills. Current techniques typically measure basic skills that are prerequisite to working with alphabets, such as phonological awareness and knowledge of letter names and sounds (e.g., Caravolas, Hulme, & Snowling, 2001; Cardoso-Martins & Pennington, 2004; Leppänen, Nieme, Aunola, & Nurmi, 2006; Lervåg & Hulme, 2010; Nikolopoulos, Goulandris, Hulme, & Snowling, 2006). A more direct approach is to measure children's performance in literacy tasks. Such measures are not only useful in evaluating children's current capabilities, but they also are among the best techniques for estimating future accomplishments.

When it comes to predicting children's future successes or difficulties in spelling, the specific literacy skill of interest here, one very useful technique is to analyze their current spelling. Spelling ability at the start of primary school can prognosticate spelling performance several years later (e.g., Garcia, Abbott, & Berninger, 2010). But before entering primary school, most children rarely spell any words correctly. It may seem impossible to differentiate future spelling performance among children who all score zero on spelling tests, but substantial progress has been made by using schemes for scoring degrees of partial correctness (e.g., Caravolas et al., 2001). For example, a child who spells *cat* as ‹C› is credited with a more advanced production than one who spells it as ‹B›, because at least one letter was written correctly. Such schemes often go a step further by giving partial credit for using letters that are not correct but are phonologically plausible; for example, spelling *cat* as ‹K› is better than spelling it as ‹B›, because the former at least uses a letter that sometimes spells [k]. These *phonological spellers* may not spell correctly, but assigning partial credit acknowledges that they are applying an understanding that letters spell sounds. The application of this *alphabetic principle* is generally considered to be the key cognitive concept underlying reading and writing (Ehri, 2005).

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However, even the basic strategy of using letters to represent sounds has to begin sometime. Is it conceivable that there is prognosticative value in even earlier, *prephonological*, spellings that show no evidence at all of conventional spelling or the most rudimentary sound-to-letter mappings? It is clear that young children in modern literate societies may write strings of letters before they understand how text encodes sound. In the study presented in this article, for example, one Brazilian child, when asked to spell the Portuguese word *bicicleta* "bicycle," wrote ‹ORP›. Such spellings would all score at the bottom in any measure of spelling competence, leaving no way to differentiate the skill levels among prephonological spellers.

Theories of spelling development all acknowledge the existence of such prephonological spellings, which are called *prealphabetic* in the influential phase theory of Ehri (2005). Prephonological spellings are characterized as random strings of letters that lack any application of the alphabetic principle (Ehri, 2005; Gentry, 1982; Gough & Hillinger, 1980). Because the alphabetic principle is the keystone of spelling, such perspectives suggest that prephonological spellings do not have enough structural properties to predict anything at all. In constructivist approaches to literacy acquisition, such as that of Ferreiro (Ferreiro, 1990; Vernon & Ferreiro, 1999), children's early spelling is characterized by cognitive stages, many of which comprise false hypotheses about how alphabetic writing works. For example, Ferreiro's theory states that early spellers believe that words must have a minimum number of letters or that each written symbol corresponds to an entire syllable (Ferreiro, Pontecorvo, & Zucchermaglio, 1996; Ferreiro & Teberosky, 1982; for counterclaims see Cardoso-Martins, Corrêa, Lemos, & Napoleão, 2006; Pollo, Kessler, & Treiman, 2009). If progress in spelling consists largely of discarding earlier ideas about writing, one would not expect very early spelling to have much to do with later, conventional, spelling.

Other researchers have drawn attention to ways in which children's prephonological spellings often bear similarities to conventional texts. A recent theme in writing acquisition explores how children learn to differentiate writing from drawing and produce increasingly conventional, letter-like forms as their understanding of writing grows (Levin & Bus, 2003; Treiman & Yin, 2011). It has often been pointed out that beginning writers tend to spell words by writing letters found in their own name, which is a piece of text with which most children are intimately familiar (Bloodgood, 1999, for English; Gombert & Fayol, 1992, for French). More recently, Pollo et al. (2009) have shown that the invented spellings of prephonological children in Brazil and the United States (mean age 4 years 8 months) contained patterns that mimicked the patterns of text that children find in their respective environments. Instead of only picking letters at random from the alphabet, children tended to use letters and letter combinations with relative frequencies that approximated the frequencies with which such letters and combinations appear in children's books written in the local language—Portuguese or English.

Pollo et al. (2009) attributed the frequency patterns in preschoolers' productions to statistical learning. Even infants are powerful statistical learners, capable of learning what sequences of syllables co-occur in a spoken text (Saffran, Aslin, & Newport, 1996). Such learning often occurs without conscious effort or awareness. Most research in statistical learning of natural language patterns has concentrated on the aural domain, but there is much evidence that children and adults learn visual patterns and sequences (Arciuli & Simpson, 2012), including the relative frequencies with which letters occur in different contexts (Kessler, 2009).

Under the statistical learning theory, therefore, there are reasons to expect that the nature of children's prephonological spellings could predict future success in conventional spelling. The patterns that prephonological children pick up may be useful later on, or they may be building blocks for more powerful or general spelling patterns. Further, children who prove to have been particularly successful statistical learners of text even at an early age may be those who are most likely to continue to be successful statistical learners of ever more patterns as they continue their acquisition of literacy.

In the current study, we sought first to check whether statistical learning of textual patterns occurs in prephonological Brazilians averaging 4 years 3 months of age (Time 1 in our study): a group of children even younger than those tested by Pollo et al. (2009). If so, we wished to see if variation among the children in the degree to which their spellings reflected such patterns at Time 1 correlated with success in later conventional spelling at Time 2, some 30 months later. We hypothesized that children whose productions of text more closely paralleled the patterns observable in their environment would be better statistical learners of other orthographic information essential to later conventional spelling. Such an outcome would not only have a practical benefit in prognosticating success or difficulty in conventional spelling, but would also constitute evidence for the statistical learning theory. Instead of treating spelling difficulty as a categorical outcome with a specific cutoff (dyslexic vs. nondyslexic), we treated spelling performance as a gradient, using the frequency measures to predict the number of correct trials in the spelling test. Such an approach is more flexible and is supported by findings that dyslexia is part of a continuum that also includes normal reading ability (Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992). Supporting this view for the case of spelling, spelling errors in children with dyslexia are very similar those of typically developing children at a younger age (e.g., Bourassa, Treiman, & Kessler, 2006; Cassar, Treiman, Moats, Pollo, & Kessler, 2005).

Table 1. Participant Characteristics.

	All Children[a]		Prephonological[b]	
Measure	*M*	*SD*	*M*	*SD*
In preschool (Time 1)				
Age in months	50.7	4.0	50.7	3.9
Words read	0.6	2.5	0.2	0.5
Letter names	12.7	7.5	11.7	7.0
Letter sounds	10.1	5.2	8.9	4.7
In primary school (Time 2)				
Age in months	81.1	3.9	81.1	3.8
TDE reading[c]	49.8	16.5	48.5	14.7
TDE writing[c]	15.6	6.7	14.7	5.9
Vocabulary[d]	15.1	3.6	14.6	4.0
Cubes[d]	14.1	3.6	14.5	3.5

Note: TDE = *Teste de Desempenho Escolar*.
[a]38 girls, 28 boys.
[b]17 girls, 14 boys.
[c]*Leitura* "reading" and *escrita* "writing" subtests of Stein (1994), number of correct words.
[d]Brazilian *Wechsler Intelligence Scale for Children–Third Edition* subtests (WISC-III; Wechsler, 2002), standardized scores. Three children (one prephonological) were unavailable for WISC testing.

Method

Participants

We recruited 76 children in the first year of preschool in private schools in Belo Horizonte, Minas Gerais, Brazil. Eight children dropped out of the study before the primary school test was administered at Time 2. Characteristics of the remaining children are summarized in Table 1. The left side of the table gives data for all children. The right side shows information for the subset of children who were classified as prephonological by the method described in the following; they were the only children whose productions were analyzed in subsequent analyses. All children were monolingual speakers of Portuguese from upper-middle-class families. Their preschool teachers reported that none had been diagnosed as having a learning or sensory disability.

Of the characteristics listed in the table, the TDE writing score (*Teste de Desempenho Escolar*; Stein, 1994) is the Time 2 response variable in the study and is discussed in the following under "Procedure." The other measures are provided in order to give a better idea of the background of the participants.

Words Read. Children were asked at Time 1 to attempt to read 15 words that Pinheiro (1996) listed as being of high frequency in books read by children. Words were presented in uppercase on cards, one at a time. Uppercase was used because preschoolers in Brazil, as in many other countries such as the United States (Treiman, Cohen, Mulqueeny, Kessler, & Schechtman, 2007; Worden & Boettcher, 1990), are much more familiar with uppercase letters than lowercase ones. This was confirmed by the fact that almost all of the spellings we elicited from them were in uppercase. In addition, six readily recognizable logos, such as that of Coca-Cola, were included as fillers, to allay frustration on the part of the children. Most children could read none of the words, and the maximum number of words read by any of the prephonological spellers was 2.

Letter Names and Sounds. Children were asked at Time 1 to name letters of the alphabet when shown to them in uppercase on a single card. The maximum score is 23, because the letters ‹K›, ‹W›, and ‹Y› are very rare in Portuguese and were not presented.

Letter Sounds. At Time 1, the experimenter presented different Portuguese phonemes, and on each of 23 trials asked the participant to point to which of six uppercase letters makes that sound. Thus, children who made any selection would get a score of about 4 by chance.

General Intelligence. Three months prior to the primary school testing at Time 2, the children's general intelligence was estimated by administering the vocabulary and cubes subtests from the Brazilian version of the *Wechsler Intelligence Scale for Children–Third Edition* (WISC-III; Wechsler, 2002). Internal consistency (Guttman's λ_2) is .79 for the vocabulary test and .82 for the cubes test. The standardized scores are presented in Table 1.

TDE Reading. In the reading subtest of the TDE administered at Time 2, 70 words were individually presented for naming. The raw score, presented here, is the number of words read correctly. Reliability of this subtest (Cronbach's α) is .988 (Stein, 1994).

Preschool attendance is optional in Brazil. In the preschools attended by the participants in this study, children learn about the shapes and names of the letters of the alphabet, and they practice invented spellings. They see a good deal of text and are read to by their teachers. Formal instruction in reading and spelling begins in the first year of primary school.

The participants were recruited as part of a longitudinal study of spelling development. We report here the first time the children performed the 12-word spelling task in preschool (Time 1) and the first time they took the TDE spelling test in primary school (Time 2).

Procedure

The preschool spelling task, which was administered near the beginning of the school year at Time 1, consisted of spelling to dictation the 12 words *chá* "tea," *flor* "flower," *pé* "foot," *bico* "beak," *dedo* "finger," *lobo* "wolf," *barata* "cockroach," *cavalo* "horse," *cigarro* "cigarette," *bicicleta* "bicycle," *tartaruga* "turtle," and *telefone* "telephone." The same order, which was selected randomly, was used for all participants. The criteria by which the words were chosen included the requirements that they be content words of varying lengths, familiar to children in oral contexts, but not overwhelmingly frequent in written text (Pinheiro, 1996). Children were tested individually in a quiet room in their schools. They were asked to spell the words as best they could. When children replied that they did not know how to write, we assured them that it was OK to make mistakes.

The TDE (Stein, 1994) was administered to the same children 30 months later at Time 2. At this point, the children were well into the first year of primary school (*ensino fundamental*) and had had a substantial amount of literacy instruction. We administered the reading subtest for background information on the participants (Table 1). The writing subtest provided the data whose relationship with the Time 1 spelling task was our main object of research. The children were asked to spell 34 individual words, which were presented orally, followed by a sentence illustrating the use of the word in context. Scoring on this standardized test is binary: Each of the 34 words is either totally correct (one point) or incorrect (zero points). Stein (1994) reported the reliability of this subtest (Cronbach's α) to be .945. As Table 1 shows, the children on average got almost half of the items correct. The range of correct responses was from 4 to 26.

Analysis

Identification of Prephonological Spellers. The data of the seven children who did not produce any identifiable letters at all at Time 1 were dropped from our analysis. Two judges who independently transcribed 120 responses agreed on their interpretation of 88% of the preschoolers' productions.

To determine whether a given preschooler produced phonological spellings with greater-than-chance frequency, we adapted a statistical technique introduced by Pollo et al. (2009). We used string-edit metrics (Levenshtein, 1965) to measure how close a child's spelling came to correctly representing the phonemes in the word being spelled. A 1,000-rearrangement Monte Carlo test (Good, 1994) was used to compute statistical significance of the hypothesis that a child was spelling phonologically. The same test also reported what string-edit score the child's 12 spellings would get if scored as spellings of randomly selected words, a measure of baseline chance. Children were considered to be prephonological spellers at Time 1, and thus retained in the study, if these statistical tests showed that their spellings were not significantly phonological ($p > .05$) and the phonological plausibility of the child's spellings was no more than 1% better than chance. By this criterion, we identified 31 of our 68 preschoolers as being prephonological spellers; their characteristics are summarized in the right half of Table 1.

Frequency Statistics. The writing of the prephonological spellers was analyzed to find how well the frequency with which they used letters correlated with the frequency they are found in text. We looked at two types of texts that children are likely to encounter frequently: children's books and their own name.

Correlations with corpus frequencies. We used the word counts of Pinheiro (1996) to estimate the relative frequency of words in texts that children typically encounter in Brazilian preschools. To avoid including words with low dispersion across texts, we omitted words that Pinheiro reported as having zero frequency in texts from the first year of primary school.

The simpler of the two corpus statistics we used was monogram counts: the frequency with which each individual letter was found in preschool texts. The counts ignored case distinctions and were weighted by word frequency. For example, the name *Ana* was found 39 times in the texts and so counted as 78 instances of ‹a› and 39 instances of ‹n›. Digram counts were computed in the same way as monogram counts, except that we counted the frequencies of immediately adjacent pairs of letters. Thus, *Ana* contributed 39 instances of ‹an› and 39 instances of ‹na›. Words that are only one letter long, such as *o* "the," do not have any digrams and therefore did not contribute to the digram counts.

For each child spelling, we counted monogram frequencies in a similar fashion. We then summed those counts across all 12 spellings the child produced, yielding a frequency count for each letter. For each child, those frequencies were then correlated with the frequencies from the corpus, yielding a single Kendall rank correlation coefficient, τ, which expressed how similar the child's monogram frequency profile was to the corpus. Because of some evidence that children tend to learn the first two or three letters of the alphabet better than other comparable letters (Treiman, Levin, & Kessler, 2007, 2012), the correlations we used were actually partial rank correlations between the child's frequency and the corpus frequency, given the letters' rank order in the alphabet.

An analogous process was used to compute a partial rank correlation coefficient between each child's digram frequencies and the digram frequencies found in the corpus, given the sum of each of the two letters' rank order in the alphabet.

Idiograms. The idiogram (from the Greek roots for "own" and "letter") frequency measure that we computed was the proportion of letters that a child used that were found in the child's own given name out of all letters that the child used. Multiple instances of the same letter counted multiple times, and both words were used when a child had a compound forename. Thus, when Ana Clara spelled *chá* as ‹AVCRPMNIBAQOUICLFAQO›, we counted 8 letters from her own name (‹A›, ‹C›, ‹R›, ‹N›, ‹A›, ‹C›, ‹L›, ‹A›) out of 20 altogether. The idiogram measure used for each child was the grand proportion across all the spellings.

Table 2. Partial Kendall Rank Correlation Coefficients (τ) Between Time 1 Spelling Frequencies and Corpus or Own-Name Frequencies.

Variable	Mean	*SD*	Largest[a]
Monograms	.310	.129	.502
Digrams	.128	.062	.237
Idiograms	.451	.270	.920

[a]Largest correlation coefficient for any participant.

Table 3. Linear Regression Predicting Primary School Spelling Scores From Preschool Text Frequency Correlations of Prephonological Spellers.

Variable	Coefficient	*SE*
Digrams	71.38***	13.87
Idiograms[a]	–9.07*	3.47

[a]Idiogram proportions squared.
*$p < .05$. ***$p < .001$.

Regression Tests. Linear regressions were performed to see how well the frequency correlations computed from the Time 1 spellings predicted the number of words the children spelled correctly in the TDE test at Time 2. The idiogram proportion was squared in order to give a more linear relation to the response variable. The age of the child in months at the time of the TDE test was also entered as a predictor.

Results

Our first research question was whether our young Brazilian participants would reflect statistical patterns of Portuguese text in their prephonological invented spellings at Time 1. Table 2 summarizes the partial Kendall rank correlation coefficients (τ) between child spelling frequencies and corpus frequencies. Eighteen of the 31 prephonological spellers had monogram correlations significantly greater than zero ($p < .05$ by a Kendall correlation test). That is, by and large, the children in our experiment preferred using letters that are found comparatively often in Portuguese texts, even after one takes alphabetical order into account.

The digram correlation numbers are, on average, smaller than the monogram correlations, but all are nonnegative. The small size of the mean is due in part to the fact that seven spellers only wrote at most a single letter for each word, thus producing no digrams at all. The correlations for these spellers were treated as zero, bringing down the average. The correlations were highly significant: Of the 24 prephonological spellers who produced spellings longer than one letter, 21 had digram correlations with text that were significantly above zero ($p < .05$), 18 of those at $p < .001$. Thus, most children in our sample used digrams that are found comparatively often in Portuguese texts.

Whether one counts by monograms or by digrams, the invented prephonological spellings of these Brazilian preschoolers reflected the statistical patterns of Portuguese text. The correlations did not closely approach the theoretical maximum of 1.0, but we did not ask the children to produce the massive amount of text that would be required to provide a closer fit to a sizable corpus. Even if it were reasonable to request such a large sample, it would be surprising indeed if the invented spellings of preliterate 4-year-olds perfectly matched the frequency patterns of texts in standard orthography.

The idiogram counts measured a rather different type of text sensitivity, in that the reference text under consideration, the child's given name, varies across subjects. On average, the children drew on their own name for almost half of the letters they wrote. Thus, our first research question has the same answer both for public texts and for this very personal type of text: The invented spellings did indeed reflect the properties of texts to which the prephonological spellers had been exposed.

The second research question was whether differences between preschoolers in these frequency measures computed at Time 1 could predict differences in the TDE, the conventional spelling test administered in primary school at Time 2. Pearson product-moment correlations between the frequency measures and the TDE scores were .322 for monograms, .656 for digrams, and –.087 for idiograms; only the correlation for digrams was significant for these zero-order correlations, $p < .001$. All three frequency measures were entered into a linear regression, along with the children's ages at the time of the primary school test. The contributions of age and monogram frequencies were both nonsignificant, and analyses of variance showed that both variables could be dropped from the model without significantly reducing its fit. Table 3 presents the results of the final, reduced model. The digram and idiogram frequencies significantly predicted a portion of the TDE spelling scores, $R^2 = .57$, $F(2, 21) = 13.91$, $p < .001$. The contribution of idiogram frequencies to predicting test scores was negative, and that of digram frequencies was positive. Thus, on average, the more preschoolers' invented spellings drew on digrams frequent in Portuguese text, the better their conventional spelling scores at Time 2. But the more their spellings drew on letters from their own name, the worse their conventional spelling scores.

Discussion

Our study shows that even preschool children around 4 years 3 months of age learn the statistical properties of text in their environment. This is the case even before children learn or apply the idea that letters in their spellings should represent sounds. Spellings like ‹VAVI› may not make phonological sense as a representation of *dedo* "finger," but the evidence suggests that the girl who wrote it was not just pulling letters at random out of the alphabet. Like most of her peers, she has implicitly learned that certain letters are more frequent than others and even that certain digrams are more frequent than others. She favors the more frequent patterns in her own invented spellings. This finding extends to an earlier age the results of Pollo et al. (2009), who documented the phenomenon in a group of Brazilians who averaged 4 years 10 months of age.

We have also verified that our participants often used idiograms, that is, they invented spellings that were heavily based on letters from their own name. For example, Matheus generated the spellings ‹MDHIUS›, ‹MOHI›, ‹MHI›, and ‹AMOUS›, each time varying the pattern somewhat but clearly favoring the monograms ‹M› and ‹H› and the digram ‹US› more than one would ordinarily expect. This general pattern too has been documented with other children (e.g., Bloodgood, 1999; Gombert & Fayol, 1992). Our study adds to these findings by using a rigorous method, the Monte Carlo rearrangement test, to show that such spellings were found among verifiably prephonological spellers.

A reasonable interpretation of these facts is that children, in general, attend to texts in their environment and implicitly internalize some of the patterns found in those texts. The fact that children may start this process in preschool provides continuity with, on one side, the now classic observations that even infants are statistical learners of spoken language patterns (Saffran et al., 1996) and, on the other side, the accumulating evidence that older children and adults implicitly learn and employ in their spelling a wide range of contextually conditioned spelling patterns that are probabilistic tendencies rather than absolute rules (e.g., Kessler, 2009). Such patterns are not formally taught in school, but spellers learn them anyway. Our claim that children learn the statistical patterns of text at such an early age may be surprising in light of findings that 4- and 5-year-old prereaders spend less than a second per page looking at text when read to by adults (Evans & Saint-Aubin, 2005). However, young children frequently engage in many other types of literacy experiences, active participation in which has been found to correlate with their understanding of properties of text such as letter shapes. Such activities include practicing letter names and trying to read and write words. The high proportion of idiograms in our subjects' spelling comes as no surprise when one considers that in terms of the degree to which young children initiate and spend time on practicing literacy skills, the foremost activity is writing the child's own name (Levy, Gong, Hessels, Evans, & Jared, 2006).

A new question that we pursue here is the predictive power of children's approximation of the frequency profile found in texts. Among our participants, a clear pattern is that prephonological preschoolers who used relatively frequent digrams in their invented spellings performed better on standard spelling tests administered 2½ years later than those who used less frequent digrams. However, contrary to our expectations, monogram frequency correlations with the later spelling test were weaker than digram correlations and had no predictive capability. ‹A›, for example, is the most common single letter in the Portuguese children's corpus, but the digram ‹AA› does not occur at all. The preschoolers who used infrequent digrams like ‹AA› in their productions appear to have had worse outcomes later on, despite the high frequency of their separate components.

Idiogram usage pointed in the opposite direction from digram usage: Children who used many letters from their own names in their invented spellings performed comparatively worse on the primary school spelling test than same-age children whose productions looked more like public texts as found in the corpus.

A reasonable interpretation of these findings is that children who attend to a wide range of texts—not limited to their own names—have begun a profitable process of implicitly learning the statistical patterns of their native language orthography, which will stand them in good stead when they are later expected to spell words conventionally. Such a pattern of learning would not be predicted by constructivist or phase theories of literacy acquisition, which posit a progression through different cognitive approaches to reading and spelling. Ehri's (2005) model recognizes the existence of a prealphabetic phase, where some printed words can be recognized, and in part written, by learning their visual patterns. Ehri cited examples such as recognizing the written word ‹camel› because it has humps in the middle or recognizing the bright yellow ‹M› of McDonald's logo. Her model, however, rejects any connection between visual learning in those early stages and the knowledge of sound-letter correspondences, which is the hallmark of the subsequent, full-alphabetic, phase of development. As she put it: "Knowing how to read golden arches does not help them learn to read words alphabetically" (p. 176). The divide is even sharper in constructivist, stage-based, theories, where children are explicitly expected to cast off early hypotheses about the nature of writing as they consolidate the cognitive insight that letters represent individual sounds (Ferreiro, 1990).

We believe, in contrast, that our data show continuity between the spellings of prephonological preschoolers and the more fully developed phonological spellings attested in primary school. Greater skill at statistical learning can account for both a high degree of implicit learning of monogram, digram, and idiogram frequencies on the one hand and, on the other hand, the skill at learning and applying sound-letter correspondences, graphotactic patterns, and exception words that is required for passing primary school spelling tests like those of the TDE. Some caution, of course, is called for when it comes to drawing very specific conclusions about causality. The children who went on to be better spellers may have done so in part because they had already learned certain orthographic patterns, which gave them a more secure platform for learning even more patterns. It is also possible that those children were better statistical learners, at least in the limited domain of alphabetic symbols; even if their preschool knowledge base itself is not very useful, their skill in learning spelling patterns could turn out to be advantageous later on. Such a conclusion is in line with research that shows that better statistical learners tend to be better readers (Arciuli & Simpson, 2012). A final possibility is that the good spellers were not intrinsically better at statistical learning than the less successful spellers but that they had the benefit of more exposure to books and other written text. More exposure would provide more data from which statistical patterns could be inferred.

From a psychometric viewpoint, we believe it is worthwhile exploring further the possibility of incorporating digram frequency correlations and idiogram proportions into tests designed to identify preschoolers who are potentially at risk of low spelling performance in primary school. Of course, with our participants being only 6 years old at Time 2, it is rather early to diagnose any of them as dyslexic, even those who missed 30 out of 34 words on the standardized spelling test. But, when combined with the substantial body of existing and ongoing research devoted to prognosticating literacy outcomes in primary school, statistical measures of corpus and idiogram frequency correlations may help round out the picture of how dyslexia develops and enable earlier and stronger predictions of outcomes. Naturally, careful work will be needed to design and normalize such tests. It could be the case, for example, that heavy use of idiograms would be a positive, not negative, indicator of success in children who are much younger than those in our study or in those who do not attend preschools that emphasize literacy education as heavily as those our participants attended. But for a first step, it is extremely encouraging that observations on prephonological invented spellings taken at the average age of 4 years 3 months significantly predict spelling success 2½ years later.

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