Knowledge of letter sounds in children from England

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This research was supported in part by NICHD Grant HD051610 and by a Leverhulme Visiting Professorship to RT.

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Abstract

Learning the sounds of letters is important for learning to decode printed words and is a key component of phonics instruction. Some letter sounds are easier for children than others, and studies of these differences can shed light on the factors that influence children's learning. The present study examined knowledge of the sounds of lowercase letters among children in England, where a government-mandated curriculum specifies the order in which letter sounds should be taught and where letter sounds are taught before names. The participants were 355 children from Nursery (mean age 4 years, 4 months), Reception (mean age 5 years, 4 months), and Year 1 (6 years, 4 months). When order of teaching was statistically controlled, children did better than expected on the initial letter of their first name and worse on visually confusable letters. Unlike the North American children in previous studies, they did not perform better on letters that had their sounds at the beginning of their names. The sonority and age of acquisition of the letter's sound were also not influential. Implications for letter teaching, particularly for children at risk of literacy problems, are discussed.

Keywords: letter knowledge, letter sounds, own-name advantage, lowercase letters, phonics

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Letters are the basic building blocks of writing, and learning about letters and their properties is an important foundation for reading and spelling (Snow, Burns, & Griffin, 1998). Particularly important is learning about the links between letters and the sounds they make in words. Letter-sound knowledge is critical for word decoding, and differences among children in reading comprehension often reflect skill differences at the word level (Perfetti, 2007). Supporting these ideas, research shows that children who are poor at providing the sounds of visually presented letters are at elevated risk of reading problems (e.g., Hulme, Bowyer-Crane, Carroll, Duff, & Snowling, 2012; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). These children's reading skills improve when they are explicitly taught about the links between letters and sounds (e.g., McArthur et al., 2018).

Researchers and educators have often focused on differences among children in letter-sound knowledge and how low scores can be sign of difficulty in learning to read. Less widely acknowledged and studied are the substantial differences that exist across letters. For example, children are generally better at providing the sound of ‹S› than the sound of ‹H› (e.g., Huang, Tortorelli, & Invernizzi, 2014; we use brackets around letters when referring to their visual forms). An understanding of the factors that contribute to such letter-related variations can shed light on the factors that influence children's letter-sound learning and can help in the design of phonics instruction. For example, if children have particular difficulty learning correspondences involving vowels, as Stuart and Coltheart (1988) suggested, then it might be advisable to spend more time teaching these correspondences.

Most studies of letter-sound knowledge in English-speaking children have been conducted in the U.S. and Canada. The order in which letters are taught varies widely across schools in these countries, making it difficult to control for order of teaching when testing hypotheses about other factors that make some letter sounds easier for children to learn than others. The present study was conducted with children in England at a time when schools generally taught the sounds of letters in an order specified by a government-mandated national literacy curriculum (Department for Education and Skills, 2001). By including the government-mandated order of teaching in our statistical models, we could control for effects of school instruction in a way that has not been possible in most previous studies. We could test whether children perform better on some kinds of letter-sound correspondences than predicted given order of teaching and worse on others.

We tested five specific hypotheses about the factors that contribute to variations across letters. According to the *own-name advantage hypothesis*, children perform better than otherwise expected on the letters of their name, reflecting their special interest in these personally important letters and their greater exposure to them in informal learning situations. Given the salience of the initial letter of the first name, most studies of the own-name advantage hypothesis have focused on this letter. Several studies have found an advantage in letter-sound knowledge for the initial letter of the first name (Huang et al., 2014, for U.S. children; Levin & Aram, 2005, and Treiman, Levin, & Kessler, 2012, for Hebrew-speaking children). Other studies, however, found little or no evidence for such an effect (Piasta, Phillips, Williams, Bowles, & Anthony, 2016, and Treiman & Broderick, 1998, for U.S. children). Here we asked for the first time whether, in the letter-sound task, children from England perform better on the initial letter of their first name than expected based on other factors.

Our letter-sound task used lowercase letters, some of which are visually confusable with others. For example, ‹d› is similar in shape to ‹b›, ‹p›, and ‹q›. When asked to name visually presented letters, U.S. and Australian children appear to perform more poorly on lowercase letters that are more visually similar to other letters than on those that are more distinctive

(Bowles, Pentimonti, Gerde, & Montroy, 2013; Huang & Invernizzi, 2014; Treiman & Kessler, 2003). We do not know of any studies that have tested the *visual confusability hypothesis* for lowercase letters of the Latin alphabet in the letter-sound task, and we did so here.

The *acrophonicity hypothesis* states that children perform better on the letter-sound task on letters whose sound appears in the first position of the letter's name than letters for which this is not the case. For example, ‹v› is acrophonic in that its sound, /v/, appears at the beginning of its name. The letters ‹l› and ‹w› are not acrophonic in that the sound of ‹l› appears at the end of its name and the sound of ‹w› does not appear in its name. Many studies show that North American children perform better with acrophonic than non-acrophonic letters in the letter-sound task (Ellefson, Treiman, & Kessler, 2009; Evans, Bell, Shaw, Moretti, & Page, 2006; Huang et al., 2014; Kim, Petscher, Foorman, & Zhou, 2010; McBride-Chang, 1999; Treiman & Broderick, 1998; Treiman & Kessler, 2003; Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998). According to the only study to have addressed this issue with children from England, acrophonicity does not have an effect (Ellefson et al., 2009). This result, if replicable, may reflect the fact that formal teaching of letter sounds and of reading and spelling begins in England when children enter Reception Year at the age of 5. Letter names are typically not taught at school until the end of Reception Year or even the following school year, Year 1. If letter-name knowledge is weak or nonexistent, children may not use letters' names to help learn and remember the letters' sounds.

The *order of speech sound acquisition hypothesis* states that letter-sound correspondences for which the sound is mastered at an early age are easier for children than those in which the sound is acquired later. According to this hypothesis, the ‹m›–/m/ correspondence should be easier than the ‹v›–/v/ correspondence because children learn to pronounce /m/ at a younger age than /v/. Justice, Pence, Bowles, and Wiggins (2006) found modest support for the order of speech sound acquisition hypothesis in their study of U.S. 4-year-olds, but their analyses were restricted to a subset of consonant letters and to the letter-name task. To our knowledge, no previous study has testing the order of speech sound acquisition hypothesis for the letter-sound task, and we do so here.

We also tested a hypothesis put forward by Stuart and Coltheart (1988) according to which children perform better in the letter-sound task on letters that correspond to phonemes that occur at the boundaries of syllables than letters that correspond to phonemes that tend to occur closer to the middles of syllables. The reason for this, according to the *syllable position hypothesis*, is that phonemes at the boundaries of syllables are more easily segmented from the rest of the syllable and more easily treated as separate phonemes. *Obstruent* consonant phonemes, which include stop consonants such as ‹p›, fricative consonants such as ‹s›, and affricates such as /d͡ʒ/, typically occur at the edges of syllables. *Sonorant* consonants, such as /m/, /l/, and /w/, tend to occupy the interior positions of consonant clusters and so tend to be closer to the middles of syllables. According to Stuart and Coltheart, sonorant consonants are therefore harder to connect to letters than are obstruents. Vowels often occur in the middle of syllables and are, according to Stuart and Coltheart's syllable position hypothesis, most difficult for children to link to letters. In the letter-sound task of Stuart and Coltheart, English Reception Year and Year 1 pupils performed better on letters with obstruent consonant sounds than on letters with sonorant consonant or vowel sounds, in line with the syllable position hypothesis. However, the only other study to have tested this hypothesis did not find consistent evidence in favor of it (Treiman et al., 1998).

Researchers have used different methods to test hypotheses about why children perform better on some letter sounds than others. Some studies have compared mean levels of performance on different groups of letters. The only two studies to date to have analyzed data from children in England—Ellefson et al. (2009) and Stuart and Coltheart (1998)—used this approach when they compared acrophonic letters to non-acrophonic letters and letters that correspond to obstruents to letters that correspond to other phonemes. A potential drawback of this approach is that letters in different groups could potentially differ in other characteristics that could influence children's performance. In the present study, we used a different approach: mixed-effects logistic regression with data at the level of individual children's responses to individual letters. This approach allows us to determine whether each letter characteristic affects performance when other characteristics are statistically controlled. We included the order in which the letter was taught in the government-mandated curriculum as a control variable, and we tested for effects of variables pertaining to visual confusability, acrophonicity, order of speech sound acquisition, and syllable position, as well as whether a letter was the initial letter of the child's first name. Although letter-related rather than child-related factors were the primary focus of the study, our models also included children's year in school—Nursery, Reception Year, or Year 1. We explored whether the effects of other variables differed as a function of children's year in school by testing for interactions.

To summarize, we used data from Nursery, Reception Year, and Year 1 children in England to test hypotheses about why children show better knowledge of some letter sounds than others. Specifically, we tested the own-name advantage hypothesis, the visual confusability hypothesis, the acrophonicity hypothesis, the order of speech sound acquisition hypothesis, and the syllable position hypothesis. Findings should shed light on the factors that are associated with letter-sound learning and should have implications for this body of knowledge should be taught and for how children learn to decode words.

Method

Participants. The participants were English students in Nursery, Reception Year, and Year 1. They were tested during the course of standardizing the York Assessment of Reading for Comprehension (YARC) Early Reading Test (Hulme et al., 2009). Twenty-one schools in England were chosen to take part in the study. The schools were selected to cover a range of socio-economic, ethnic, and geographic backgrounds, including suburban, rural, and inner city schools. (Children from Northern Ireland and Wales also participated in the standardization, but we do not analyze their data because literacy teaching in these areas differs in some respects from literacy teaching in England.) Within each school, children were randomly selected to take part based on their date of birth. Table 1 provides information about the number of students at each grade level and their ages. The lower number of pupils in Nursery than in other years reflects the fact that some of the selected schools did not have nurseries.

Procedure. We used the data from the extended letter-sound knowledge test of the YARC. For this test, which took about 5 minutes, children received a booklet in which each lowercase letter appeared on a separate page in black print on a white background. The letters were in a scrambled order, not alphabetical, in a font commonly used in English schools. Children were asked to say the sound of each letter. The examiner scored the child as correct or incorrect following the sounds that are taught for letters in England. These include the “short” sounds of vowels and the “hard” sounds of ‹c› and ‹g›. The booklet included six digraphs, but we did not include these in our analyses.

Results

Mixed-effect model analyses were conducted using the software package lme4 (Bates, Mächler, Bolker, & Walker, 2015) within the R environment (R Core Team, 2018; R version 3.5.0), selecting generalized mixed-effects models with a logit link function and treating children as random effects. The analyses were done at the level of individual children’s responses to individual letters, with a correct response coded as 1 and an incorrect response as 0. The data and analysis scripts may be found at https://osf.io/kn365/?view_only=db636fa956f543efa8e8be8e02c155f6.

We coded each letter for the order in which it is taught in the government-mandated national literacy curriculum that, at the time of the study, was used in most schools in England (Department for Education and Skills, 2001). Letter order ranged from 1 for ‹s› to 26 for ‹q›, and we centered the values for use in our analyses. To assess the visual confusability of a letter with other lowercase letters in a way that would be suitable for children, we used data from a study in which 65 U.S. children with a mean age of approximately 5 ½ years judged which of two lowercase letters matched a target letter (Popp, 1964). We calculated the mean number of confusions of each letter with each of the other 25 letters, and we used the centered values in our analyses. Among the most confusable letters by this measure are ‹b›, ‹d›, ‹p›, and ‹q›. The letters ‹h› and ‹u› are also high in visual confusability because children sometimes confuse them with each other and with ‹n›. Each letter was also coded for whether it is acrophonic; that is, whether its name begins with the sound that is taught for it. We classified ‹b›, ‹d›, ‹j›, ‹k›, ‹p›, ‹t›, ‹v›, and ‹z› as acrophonic and other letters as nonacrophonic. We did not make distinctions within the category of nonacrophonic letters given the number of other variables included in the models. Letters that correspond to vowels and to the eight consonant phonemes listed by Shriberg (1993) as being acquired early (/m/, /b/, /j/, /n/, /w/, /d/, /p/, /h/) were coded as corresponding to earlier acquired phonemes. Letters that correspond to consonants in Shriberg's middle and late groups were coded as later acquired, and ‹q› and ‹x› were also so coded because their taught sounds include consonant clusters. To test for effects of sonority, we coded each letter as corresponding to an obstruent phoneme (a stop, fricative, or affricate) or a sonorant phoneme (a nasal, liquid, glide, or vowel). We did not code ‹q› and ‹x› for sonority because they do not map to a single phoneme. We also coded whether the letter on a trial appeared in the first position of the child's first name. (For reasons of confidentiality, we did not have information about the letters of the name beyond the initial letter.)

Our first model included the variables that were defined for all letters of the alphabet—order of teaching, acrophonicity, visual confusability, and order of sound acquisition—as well as initial position of child's first name and child's year in school. As expected, we found a main effect of order of teaching, such that children tended to perform more poorly on letters that are later in the teaching sequence than letters that are earlier ($b = -0.10$, $SE = 0.01$, $p < .001$; further details about this and the other models may be found in the supplemental materials in the above-mentioned repository). The effect of order of teaching is shown in Figure 1, which plots the proportion of correct responses pooled across all children as a function of the order of the letter in the government-mandated curriculum. There was also an effect of own-name membership, such that children tended to perform better on the initial letter of their first name than expected on the basis of other factors ($b = 0.89$, $SE = 0.23$, $p < .001$). To illustrate, the mean proportion of correct responses was .83 when a letter was the initial letter of a child's first name and .74 when it was not. Visual similarity also had a significant effect. If a letter was more visually similar to other letters, children tended to perform more poorly on it than expected on the basis of other factors ($b = -0.94$, $SE = .11$, $p < .001$). We illustrate this effect in Figure 1 by scaling the darkness of the points by the measure of visual confusability, with lighter points for letters that are more visually similar to others and darker points for letters that are more visually distinctive. As the figure shows, some of the letters on which children performed more poorly than anticipated given the order of teaching, including ‹u› and ‹q›, were quite visually confusable with others. Acrophonic letters (coded as 1) were not easier than nonacrophonic letters (coded as 0; $b = -0.14$, $SE = .08$, $p = .09$). Also, letters that correspond to earlier acquired sounds (coded as 1) did not give rise to significantly better performance than letters that correspond to later acquired sounds (coded as 0; *b* = -0.01, *SE* = 0.08, *p* = .94). Not surprisingly, there were statistically reliable differences across year groups, with the proportion of correct responses being .21, .84, and .93 for children in Nursery, Reception Year, and Year 1, respectively. Treating Nursery as the reference level, the model showed a significant superiority for Reception (*b* = 4.87, *SE* = 0.30, *p* < .001) and Year 1 students (*b* = 6.19, *SE* = 0.31, *p* < .001).

A potential concern with preceding analysis involves the status of ‹h›. We coded this letter as nonacrophonic because its name as standardly pronounced does not begin with /h/, its sound. However, this decision may be questioned because the letter's name is sometimes pronounced with an initial /h/ in colloquial speech in England. When we omitted ‹h› from the model, acrophonicity remained nonsignificant and the overall pattern of significant and nonsignificant results did not change.

We fitted another model to determine whether the sonority of the phoneme to which a letter corresponded was influential. This model excluded data for ‹q› and ‹x›, which as discussed earlier were not coded for sonority. In addition to the effect of sonority, we included the effects that were significant in the preceding analyses, namely order of teaching, initial letter of child's first name, visual confusability, and year group. The syllable position hypothesis predicts that obstruents (coded as 1) should be easier than sonorants (coded as 0), but we did not find a significant effect of sonority (*b* = 0.09, *SE* = 0.08, *p* = .28).

To determine whether the effects of other variables depended on year group, we fitted a model that included the interaction of each of order of teaching, initial letter of child's first name, and visual similarity with year group. According to a likelihood-ratio test, the model that included the interactions was a significantly better fit than a model that included the main effects of order of teaching, initial letter of name, visual similarity, and year group but not the interactions ($p < .001$). This reflected the presence of a significant interaction between order of teaching and the contrast between Nursery and Reception Year, such that order of teaching had a stronger impact in Reception Year than in Nursery. We simplified the model by removing the nonsignificant interactions of order of teaching with initial letter of name and visual similarity, and we confirmed that this did not weaken the model significantly by a likelihood-ratio test. Table 2 shows the details of the final model.

Discussion

Learning the sounds of letters is a crucial step in the process of learning to read in an alphabetic orthography and one that is problematic for some children. In the present study, we tested a number of hypotheses about the factors that influence letter-sound learning by examining data from English children who were taught the sounds of letters of the alphabet in a prescribed order, before they learned the letter's names.

As we had anticipated, knowledge of letter sounds was better for letters that were taught earlier in the government-recommended sequence than for letters that were taught later. Order of teaching was especially influential during Reception Year, when much of the teaching about letter sounds takes place. Statistically controlling for teaching order in our analyses permitted a more sensitive examination of other factors that influence children's learning than has been possible in previous studies.

We found a significant advantage for the initial letter of the first name in letter-sound knowledge, one that did not weaken reliably across the age range covered by our study. Previous studies, as discussed in the introduction, have found mixed evidence on whether children perform better on the initial letter of their first name than otherwise expected in the letter-sound task. Our results strengthen the evidence for an own-name advantage. Children's elevated performance on the initial letter of their first name is likely to reflect special attention to this letter and additional exposure to its oral and written form outside of school. For example, letter-related talk between parents and their young children often focuses on the initial letter of words and on children's names in particular, and children sometimes refer to the initial letter of their name as "my letter" (Farry-Thorn, Treiman, & Robins, submitted; Treiman et al., 2015; Welsch, Sullivan, & Justice, 2003). Interestingly, we found an advantage for the initial letter of the first name even though we presented the letters to the children in lowercase rather than uppercase, as they appear at the beginnings of printed names. This result, which is similar to that of Treiman and Kessler (2004) for the letter-name task, suggests that children's knowledge about the initial letter of their first name is not specific to a particular case but is more abstract. Developing abstract letter identities is an important part of literacy development (Thompson, 2009), and the findings point to early emergence of such knowledge for at least the first letter of the name.

Items that are confusable with one another cause difficulty for learning in a number of domains, and we saw effects of visual confusability in the letter-sound task of the present study. When order of teaching was controlled, letters that were more visually confusable with others led to poorer performance in the letter-sound task than letters that were less visually confusable. These results extend previous findings with the letter-name task (Bowles et al., 2013; Huang & Invernizzi, 2014; Treiman & Kessler, 2003) to the letter-sound task and show that visual confusability is problematic throughout the age range examined here. Indeed, several studies have found that some of the errors that children make when decoding words reflect the visual confusability of letters and that such errors may persist for many years in children with reading difficulties (Liberman, Shankweiler, Orlando, Harris, & Berti, 1971; Werker, Bryson, & Wassenberg, 1989).

With children from England, Ellefson et al. (2009) did not find support for the acrophonicity hypothesis—the idea that children perform better on the letter-sound task when the letter begins with its sound than when it does not. The present study found null results regarding acrophonicity using better statistical controls. This finding, which contrasts with the strong support for the acrophonicity hypothesis that has been found in studies of U.S. and Canadian children (Evans et al., 2006; Huang et al., 2014; Kim et al., 2010; McBride-Chang, 1999; Treiman & Broderick, 1998; Treiman & Kessler, 2003; Treiman et al., 1998), makes sense given that the literacy curriculum in England teaches the sounds of the letters before the names. The results point to cross-cultural differences in letter-sound learning even within the same language. An advantage in the sound task for letters with acrophonic names is found in some cultures but not others, depending on whether letter sounds are taught when children already have a strong knowledge of letter names.

Two hypotheses pertaining to the characteristics of the sounds that letters represent were not supported in our study. One of these was the order of speech sound acquisition hypothesis (Justice et al., 2006), which states that children find it easier to learn the sounds of letters that correspond to earlier acquired speech sounds than the sounds of letters that correspond to later acquired speech sounds. Another was the syllable position hypothesis (Stuart & Coltheart, 1988), which states that it is harder for children to learn the sounds of letters that correspond to sonorant consonants and vowels than to learn the sounds of letters that correspond to obstruent consonants. This latter result suggests that English-speaking children's difficulties in reading vowels (e.g., Fowler, Liberman, & Shankweiler, 1977) does not reflect an intrinsic difficulty in learning letter-sound correspondences for these sounds. Rather, the difficulty probably reflects the fact that vowels sometimes do not have their taught correspondences in the English words.

To summarize, we found that, when letter sounds are explicitly taught in advance of letter names, two factors contribute to differences in performance across letters beyond order of teaching. The first is the presence of the letter in the initial position of a child's first name, an index of informal exposure and interest. The second is the visual similarity of the letter to others. Factors related to the types of sounds that the letters represent in words do not appear to be influential.

Explicit teaching of letter-sound correspondences is “the fastest, most efficient way of making children efficient readers, both for pronunciation and for comprehension purposes” (Dehaene, 2001, p. 23), and our results have some implications for how this body of knowledge should be taught. It has been suggested that the order of teaching of letter-sound correspondences, especially for younger children, should consider the age at which children acquire the speech sounds (Dechant, 1970; Jones, Clark, & Reutzel, 2013; Lehr, 1996). Our failure to support the order of speech sound acquisition hypothesis casts doubt on this idea. Some discussions of letter-sound learning that are directed at educators imply that acrophonicity influences children in all cultures and have made recommendations that are based on this assumption, such as that letters with acrophonic names be taught before those with nonacrophonic names (Jones et al., 2013). However, our results point to cross-cultural differences in the effects of acrophonicity. Our results do suggest that more time should be spent on lowercase letters that are visually very similar to other letters, perhaps using additional instructional techniques. Separating visually similar letters from one another in the sequence of instruction may also be helpful (Groff, 1972). Thus, although it makes sense to teach commonly used letters before less common ones, the visual characteristics of the letters should also be considered. Our results further suggest that it may be useful to take advantage of the letters in children’s names when teaching letter-sound correspondences (Jones et al., 2013). For example, a child may be more motivated to learn about a letter when a teacher points out that the letter is in a classmate’s name.

Some limitations of the present study must be considered when drawing conclusions. There were fewer children at the Nursery level than the other levels, and the letters were presented in the same order to all children. We did not observe teachers in the classrooms to assess the degree to which they adhered to the government-mandated teaching sequence and the time they spent on each letter. Also, we did not consider the possible influence of letters in the child's name beyond the initial letters of the first name. Despite these limitations, we believe the study has some important implications for the learning and teaching of alphabet knowledge. Even when the letter set is fairly small, as it is with the Latin alphabet, learning about letter sounds can be difficult for some children. An awareness of the factors s that cause certain letters to be more especially difficult can help educators deal with these problems. Learning about the symbols of a writing system is a more protracted when the number of symbols is larger (e.g., Nag, Snowling, Quinlan, & Hulme, 2014), and further work will be needed to determine the applicability of the principles examined here to other symbol systems.

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Table 1

Descriptive Information for Children in Each Year Group

Year group	N	Mean age (years; months)	Age range
Nursery	74	4;4	3;7—5;4
Reception	139	5;4	4;6—5;10
Year 1	142	6;4	5;8—7;8

Table 2

Results of Final Mixed-Model Analysis

Random effect and slope	Variance	*SD*			
Participant (Intercept)	3.17	1.78			
Fixed effects	*b*	*SE*	*z*	Odds ratio	*p*
Intercept	-2.30	0.24	-9.76	0.10	< .001
Order of teaching	-0.08	0.01	-8.02	0.92	< .001
Initial letter of child's first name	0.89	0.23	3.84	2.44	< .001
Visual confusability	-0.99	0.11	-9.39	0.37	< .001
Reception vs. Nursery	4.90	0.30	16.48	134.28	< .001
Year 1 vs. Nursery	6.06	0.31	19.38	427.16	< .001
Reception vs. Nursery × order of teaching	-0.04	0.01	-3.36	0.96	< .001
Year 1 vs. Nursery × order of teaching	-0.00	0.01	-0.00	1.00	.998

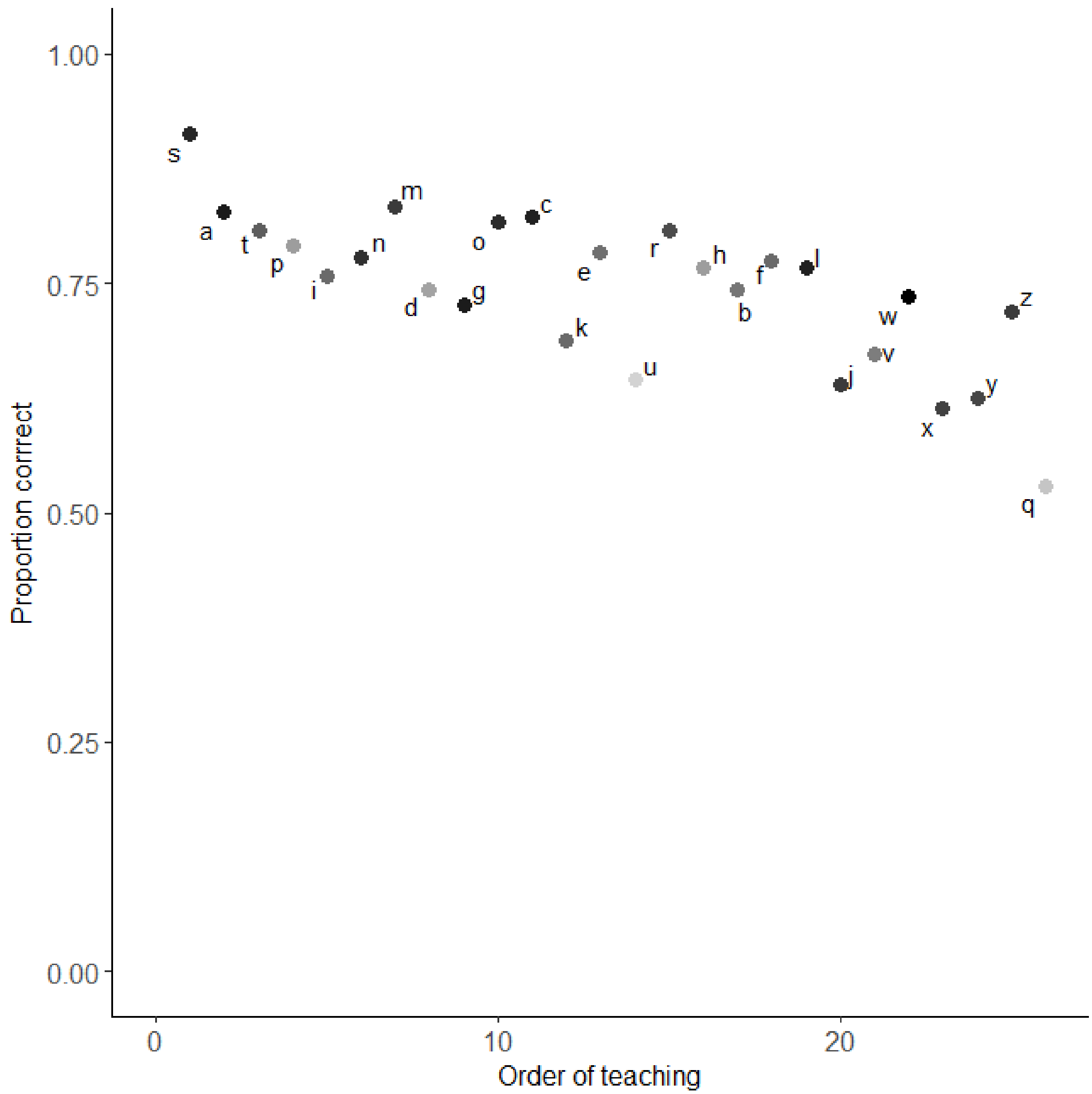

Figure 1. Proportion of correct responses pooled across all children as a function of order in which letters are taught in the government-mandated curriculum. Darker points correspond to letters that are less visually confusable with other letters and lighter points correspond to letters that are more visually confusable.