

Lexical classification and spelling: Do people use atypical spellings for atypical pseudowords?

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Abstract Many English phonemes have more than one possible spelling. People's choices among the options may be influenced by sublexical patterns, such as the identity of neighboring sounds within the word. However, little research has explored the possible role of lexical conditioning. Three experiments examined the potential effects of one such factor: whether an item is typical of English or atypical. In Experiment 1, we asked whether presenting pseudowords as made-up words or the names of monsters would cause participants to classify them as atypical and spell phonemes within these pseudowords using less common patterns. This was not found to be the case in children (aged 7–12 years) or adults. In Experiment 2, children aged 10–12 and adults spelled pseudowords that contained phonologically frequent or infrequent sequences and, in Experiment 3, adults chose between two possible spellings of each of these pseudowords. Adults, but not children, used more common spellings in pseudowords that contained frequent sequences and that thus seemed more typical of English. They used fewer common spellings in pseudowords that contained infrequent sequences and therefore seemed atypical. These results suggest that properties of pseudowords themselves can affect lexical classification and hence spelling.

Keywords Spelling · Orthography · Lexical classification · Pseudowords · Children · Adults

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Introduction

In English, as in many other writing systems, there is often more than one way to spell a particular sound. The phoneme /k/, for example, is represented by different letters in *cattle*, *kettle*, *chorus*, *quiche*, and *back*. When people need to write a word that is unfamiliar to them, how do they choose among the options?

Research shows that people sometimes vary their choice of spellings for a phoneme depending on such factors as the position in which the phoneme occurs and the neighboring sounds or letters. That is, their choice of spelling may be *conditioned* by these factors. *Sublexical* influences such as these have been the focus of most work on conditioned sound-to-spelling correspondences. For example, Hayes, Treiman, and Kessler (2006) examined how U.S. children and adults choose among spellings of /f/, /k/, /l/, and /tʃ/ when these sounds appear at the ends of single-syllable pseudowords. In this context, there are two main spelling options for these sounds. The first is the *extended spelling*—<ff>, <ck>, <ll>, or <tch>—and the second is the *simple spelling*—<f>, <k>, <l>, and <ch>. English words in which the preceding vowel sound is short and the rime would otherwise be spelled with only two letters generally have the extended spelling (e.g., *ruff*, *rock*). The simple spelling is most often used when there would be more than two letters in the rime. This is generally the case with long vowels (e.g., *reef*, *rake*). Hayes et al. found that spellers in school grades 2, 3, and 5 and in university were significantly more likely to use the extended spellings of /f/, /k/, /l/, and /tʃ/ after short vowels than after long vowels. The influence of context was stronger in older participants than in younger ones. Other studies have pointed to additional cases in which spellers' choices are conditioned by sublexical context and have shown that sensitivity to context is often greater in more experienced spellers than in less experienced spellers (e.g., Juul, 2005; Treiman & Kessler, 2006; Treiman, Kessler, & Bick, 2002; see Treiman & Kessler, 2014, for review).

A smaller body of research has examined *lexical* conditioning of sound-to-spelling correspondences, including effects having to do with a word's morphology or part of speech. In French, for example, final /ɛt/ may be spelled in several ways (e.g., <ète>, <aite>, <ette>). However, <ette> is the only correct spelling if the word is a diminutive, a form that expresses smallness or affection (e.g., *fillette* 'little girl'). As early as 8–9 years of age, French children are more likely to use the <ette> spelling if a word is presented as a diminutive than if it is not (Pacton, Fayol, & Perruchet, 2005). Another example of lexical conditioning due to morphology comes from English, in which word-final /ks/ appears as both <x> and <ks>. The former spelling is used for single-morpheme words, such as *box* or *fix*, and the latter is used when the final /s/ is an inflectional ending, showing that a word is a plural, as in *beaks*, or a third-person singular verb such as (*the dog*) *barks*. Mitchell, Kemp, and Bryant (2011) found that some British adults, although not all, followed this pattern when pseudowords were presented in sentences that made them appear either inflected or uninflected.

In the present study, we focused on one form of lexical influence that has been largely ignored in the literature—the perceived origin of a word. In English, as some other languages, words come from a variety of sources. For example, *back* is a part of the native Germanic vocabulary. In contrast, *trek* was borrowed more recently

from Afrikaans. The spellings of words sometimes reflect their origins. *Typical* words, those in what Carney (1994) calls the basic system of the English vocabulary and what Albrow (1972) calls System 1, follow spelling patterns like the one described earlier about final consonant extension. Words outside of the basic category, which we call *atypical*, sometimes deviate from the normal spelling patterns. For example, /k/ is unusually spelled in imports such as *trek*, *quiche*, and *yakka* (Australian slang for ‘work’, of Aboriginal origin). In the three experiments reported here, we asked whether people’s spelling of phonemes in pseudowords would vary if they had reason to classify the pseudowords as atypical.

Experiment 1 was designed to determine whether giving people certain types of instructions when asking them to write pseudowords could cause them to classify the items as atypical and thereby influence their spelling of specific target phonemes within them. For example, participants who are asked to spell pseudowords that are explicitly described as “made-up” or “silly” or as the names of monsters might classify the items as atypical and thus choose less common letters for the target sounds. In contrast, participants who are asked to write pseudowords that are presented as real but infrequent words might use the most common spellings of the targets. Studying the effects of instructions is important not only because it may shed light on lexical classification and its effects on spelling but also for methodological reasons. Instructions like all of those described above have in fact been used in previous studies, especially to engage young children in spelling. Thus, while some researchers asked participants to write pseudowords as though they were ordinary words of English, or as naturally as possible (Martin & Barry, 2012; Treiman et al., 2002), other researchers explicitly told participants that the pseudowords were made up (Pacton, Sobaco, Treiman, Fayol, & Treiman, 2013; Ritchey, 2008) or described them as “silly”, “funny”, or the names of monsters (Hayes et al., 2006; Kohler et al., 2007; Pollo, Kessler, & Treiman, 2009). No previous study has determined whether these types of instructions give rise to different spelling choices, and we addressed this issue in Experiment 1.

In Experiments 2 and 3, we examined a different and potentially more direct way to change people’s lexical classifications—changing the nature of the items themselves. We did so by manipulating the non-target phonemes in the pseudowords. When a word contains less common phonemes and sequences of phonemes, that is, less common *phonotactic* patterns, this may provide a clue that it belongs to the atypical category of words that originated from other languages. This, in turn, may influence participants’ spelling choices. For example, the /vl/ combination at the start of *Vladivostok* could suggest that the word has been borrowed from another language and that the ending <ck>, required in typical English words after a single <v>, is not found here.

Experiment 1

This experiment was designed to determine whether adults’ and children’s spelling of word-initial target sounds in pseudowords would vary according to whether the pseudowords were described as words that were real but infrequent, words that had

been made up by the researcher, or the names of crazy monsters. These instructions were designed to reflect the types of instructions given in previous studies and to test whether instructions that might be expected to induce different classifications of the pseudowords could lead to different patterns of spelling choices. The participants were children who could be expected to be still acquiring spelling knowledge (Grades 2–3), children consolidating their spelling skills (Grades 5–6), and skilled adult spellers.

Method

Participants

The adult participants were 53 first-year psychology students (11 male) at the University of Tasmania, Australia, with a mean age of 23.1 years ($SD = 8.3$), participating for course credit. The child participants, from three middle-class schools near the university, were 45 children (20 boys) in Grades 5 and 6 (mean age 11.9 years, $SD = 0.5$) and 42 children (18 boys) in Grades 2 and 3 (mean age 8.9 years, $SD = 0.5$). All participants could read and write only in English. Two additional children who completed only one of the two sessions were not included in the final sample.

Materials

Sixty disyllabic pseudowords were developed, each beginning with a consonant that could be spelled in two or more ways (see Table 1). One spelling of the target phoneme was most common across the English vocabulary as a whole and also most common when the phoneme occurs in word-initial position followed by the specific vowels that were used in the experiment. Each target phoneme also had one to four less common spellings. For example, word-initial /t/ occurs most commonly as <ɾ>

Table 1 Target phonemes and spellings in Experiment 1

Target phoneme	Most common spelling of target	Less common spelling(s) of target	Examples
/n/	<i>n</i>	<i>kn, gn</i>	<i>not, knot, gnat</i>
/r/	<i>r</i>	<i>wr, rh</i>	<i>rider, writer, rhino</i>
/k/	<i>c</i>	<i>ch, k, kh</i>	<i>cart, chord, key, khaki</i>
/f/	<i>f</i>	<i>ph</i>	<i>fun, phone</i>
/h/	<i>h</i>	<i>wh, j</i>	<i>hot, who, jalapeno</i>
/g/	<i>g</i>	<i>gu, gh</i>	<i>gone, guide, ghost</i>
/s/	<i>s</i>	<i>c, sc, ps, sz</i>	<i>sell, cell, science, psychic, Szechuan</i>
/z/	<i>z</i>	<i>x</i>	<i>zoo, xylophone</i>
/w/	<i>w</i>	<i>wh</i>	<i>will, while</i>
/ʃ/	<i>sh</i>	<i>ch, sch</i>	<i>shift, chef, schnitzel</i>

(as in *rider*), and the less common spellings are <wr> (as in *writer*) and <rh> (as in *rhino*). For each initial target, the three following vowels listed in Table 1 were used twice each to create the 60 pseudowords (see Appendix for full list). As much as possible, we avoided constructing pseudowords whose first syllable was a real word to avoid reliance on obvious analogies.

The 60 pseudowords were divided into three matched lists of 20. Four low-frequency real words (e.g., *poncho* for children, *pithy* for adults) were included in the list of words presented as real to increase the likelihood of participants knowing, or having heard of, some items and thus of believing that all of the pseudowords were English words. Four filler pseudowords (e.g., *prabble*) were added to each of the other two lists. All three lists were thus 24 items long. The response sheet for the monster names included a picture of a different monster for each pseudoword.

Procedure

Participants wrote the pseudowords in a single small-group session of about 30 min (adults) or two sessions of about 20 min each (children). The experimenter asked participants to spell the words as best as they could, with each list introduced by a different set of instructions:

Real words: “These words are real, but they are fairly uncommon, so you may not have heard most of them before.”

Made-up words: “These are some words that I have just made up myself.”

Monster names: “In fact, these aren’t just words, but the names of some crazy monsters that live on the planet Zog, so they might be fairly funny!”

The three lists were presented in counterbalanced order. Each list was rotated through the three types of instruction to limit any effects of order or of individual words. At the end of the session (or second session for children), participants were debriefed about the so-called real words.

Results

Responses that did not use any of the spellings of the target listed in Table 1 were uncommon, occurring less than 3 % of the time in each age group. We eliminated these spellings from consideration because they could represent mis-hearings of the pseudowords. We then calculated for each participant the proportion of responses that used the most common spelling relative to the total number of responses that

Table 2 Mean proportion of uses of most common spellings for target phonemes in Experiment 1

Grade	Instructions		
	Real words (<i>SD</i>)	Made-up words (<i>SD</i>)	Monster names (<i>SD</i>)
2–3	0.93 (0.06)	0.96 (0.04)	0.96 (0.05)
5–6	0.94 (0.06)	0.94 (0.04)	0.94 (0.05)
University	0.88 (0.09)	0.89 (0.08)	0.87 (0.10)

used the most common and the less common spellings. The results, shown in Table 2, reveal that participants at all age levels responded very similarly in the three instructional conditions. The children, however, produced more of the most common spellings than did the adults. These impressions were confirmed by a mixed-effect model analysis that was carried out with data at the trial level and, given that the dependent variable was binary, used a logit link function (Bates, Maechler, & Bolker, 2011). Instructions and age group were fixed factors, the random factors being a separate intercept for each participant and item and separate random slopes for participants based on instructions. The results showed that children in Grades 2 and 3 and children in Grades 5 and 6 produced the most common spellings at a significantly higher rate than adults did ($\beta = 1.31$, $SE = 0.17$, for the contrast between Grades 2/3 and adults; $\beta = 0.95$, $SE = 0.16$, for the contrast between Grades 5/6 and adults; $p < .001$ for both). In addition, there was a trend for children in Grades 2 and 3 to produce a higher proportion of most common spellings than children in Grades 5 and 6 ($\beta = 0.35$, $SE = 0.18$, $p = .055$). There was no significant effect of instructions. Adding the interaction between instructions and age group did not significantly improve the fit of the model according to a log likelihood test.

Discussion

The central finding of this experiment was that, when spelling unfamiliar items, neither children nor adults were affected by whether they were told that the items were real, made-up, or the names of fantastical creatures. That is, telling participants that words were made-up or the names of monsters did not appear to lead them to classify the words as originating from a different language and to use less common spelling patterns for them. A subsidiary finding is that children used the most common spellings of the target phonemes significantly more often than adults. It is likely that the children had had less exposure to the less common spellings than the adults in their more limited reading experience, and thus did not have the knowledge to produce many alternative spellings.

Although varying the instructions did not seem to induce participants to classify pseudowords as atypical and to use less common spellings for the phonemes within them, it is possible that changing the nature of the pseudowords themselves would have this effect. We addressed this question in Experiment 2.

Experiment 2

The aim of this second experiment was to examine whether adults and children would classify pseudowords as atypical if the pseudowords contained sequences of phonemes that were infrequent or non-existent in English and would, in that case, use less common spellings for target phonemes in the pseudowords. In this experiment, target phonemes were located in either word-initial or word-final

position. Pilot testing revealed that the items were difficult for children in Grades 2 and 3, and thus we restricted our child sample to Grades 5 and 6.

Method

Participants

Adult participants were 42 first-year psychology students (10 male) at the University of Tasmania. They received course credit for their participation, and none had participated in Experiment 1. Their mean age was 22.4 years ($SD = 6.9$). There were 39 child participants (26 male), in school grades 5 and 6 at two middle-class primary schools near the university. Their mean age was 11.3 years ($SD = 0.5$). All participants had English as their first language.

Materials

Sixty-four monosyllabic pseudowords were developed. As Table 3 shows, half had one of four word-initial target phonemes (e.g., /k/ in /krʌsp/, possible spelling *crusp*) and half had one of four word-final target phonemes (e.g., /k/ in /brek/, possible spelling *breck*). Each target had at least two alternative spellings. These spellings were identified as either most common for the following or preceding phoneme and the word position (e.g., <c> for word-initial /k/ before <r>, <l>, and <p>) or less common (e.g., <k> or <ch> for word-initial /k/ before these sounds). The pseudowords with word-final target sounds had a short vowel sound immediately before the vowel, meaning that the most common spelling of the target was extended (e.g., <ck> for word-final /k/) rather than simple (e.g., <k>). The pseudowords were paired so that, for two pseudowords with the same target sound in the same position (e.g., word-initial /k/), one contained a sound sequence that was frequent in English (e.g., the /sp/ in /krʌsp/) and the other contained a sound sequence that was rare or non-existent (e.g., the /fp/ in /krʌfp/). (See Appendix for full list.) As far as possible, we avoided creating pseudowords that were only one phoneme different from a real English word.

Table 3 Target phonemes and spellings in Experiment 2

Target position	Target phoneme	Most common spelling	Less common spelling(s)	Examples
Initial	/f/	<i>f</i>	<i>ph</i>	<i>fun, phone</i>
	/k/	<i>c</i>	<i>k, ch</i>	<i>cat, key, chord</i>
	/ʃ/	<i>sh</i>	<i>ch, sch</i>	<i>shift, chef, schnitzel</i>
	/w/	<i>w</i>	<i>wh</i>	<i>will, while</i>
Final	/f/	<i>ff</i>	<i>f, ph</i>	<i>staff, if, graph</i>
	/k/	<i>ck</i>	<i>k, c, ch, q</i>	<i>tick, trek, bloc, tech, Iraq</i>
	/l/	<i>ll</i>	<i>l</i>	<i>pill, gel</i>
	/tʃ/	<i>tch</i>	<i>ch</i>	<i>pitch, which</i>

Thirty-two undergraduates from the same university who were not further involved in the study rated each spoken item on a scale from 1 = *Nothing like a real English word* to 7 = *Just like a real English word*. Overall, the students rated the pseudowords containing a phonotactically frequent sequence as more wordlike ($M = 4.86$, $SD = 1.25$) than the pseudowords containing a phonotactically infrequent sequence ($M = 2.53$, $SD = 1.04$). However, the mean ratings for one of the original pairs showed the opposite pattern. Another two pseudowords that contained a frequent sequence received a mean rating of less than 3.5, and another three pseudowords that contained an infrequent sequence received a mean rating of greater than 3.0. We replaced these items and had their pairs rated by a new group of 14 adults, who rated the phonotactically frequent items in all of new pairs as more like English words than the phonotactically infrequent items. In preparing the final list of items, we also changed the vowels in one of the original pairs to make it easier to pronounce. The final list was made into four different orders for presentation.

Procedure

Participants were seen individually or in pairs in a quiet room, in a single session of about 30 min (adults) or two 20-min sessions (children). The consent forms for this experiment noted that participants would be asked to write “some new words”, but after this, no explicit instruction was given about the nature of the items. The experimenter pronounced each of the 64 pseudowords aloud, in one of four orders. Participants were asked to repeat each pseudoword, until they said it correctly, and were then asked to spell it.

Results

Table 4 shows the proportion of times that participants produced the most common spelling of the target sound as a function of whether the target was initial or final and whether the item was typical or atypical. We excluded from the analyses responses that included an implausible spelling of the target (e.g., <p> for /h/). We also excluded responses to items containing a word-final target that did not use a single letter for the short vowel (e.g., *broule* for /brʌl/) in order to avoid confounding length of vowel pronunciation with length of vowel spelling. Fewer than 4 % of the spellings were omitted for these reasons. As in Experiment 1, we then calculated, for each participant, the proportion of responses using the most

Table 4 Mean proportion of choices of most common spelling for target phonemes in Experiment 2

Target position	Children		Adults	
	Typical (<i>SD</i>)	Atypical (<i>SD</i>)	Typical (<i>SD</i>)	Atypical (<i>SD</i>)
Initial	0.94 (0.08)	0.94 (0.07)	0.87 (0.12)	0.81 (0.15)
Final	0.66 (0.21)	0.63 (0.22)	0.87 (0.12)	0.80 (0.13)

common spelling relative to the overall number of responses that used the most and the less common spellings. As Table 4 shows, adults used the most common spelling of the target more often in typical and atypical pseudowords, regardless of the target's word position. In contrast, children used the most common spelling more often for initial targets than for final targets, regardless of item type.

These impressions were confirmed by mixed model analyses carried out at the trial level. The models included random intercepts for each participant and item pair, random slopes for participants as a function of item type and position, and random slopes for item pairs as a function of item type. A first model included the fixed factors of item type, age group, and target position. A second model that included all of the two-way interactions accounted for significantly more variance than the first model according to a log likelihood test ($\chi^2(4) = 44.44, p < .001$). A third model that included the three-way interaction did not account for significantly more variance than the second model, and we therefore report the results from the second model. The main effect of age group was significant ($\beta = 0.98, SE = 0.31, p = .002$). There was a main effect of item type ($\beta = 0.57, SE = 0.19, p = .002$) that was qualified by an interaction with age group ($\beta = 0.44, SE = 0.18, p = .014$). There was no main effect of position, but position interacted with age group ($\beta = 2.44, SE = 0.37, p < .001$). Given the interactions involving age, we conducted follow-up analyses using the factors of position and item type to examine the results for adults and children separately. Adults showed no effect of position but a significant effect of item type ($\beta = 0.59, SE = 0.15, p < .001$). Regardless of whether the target phoneme was initial or final, adults showed greater use of the most common spelling when the pseudoword was typical of English than when it was atypical. Children showed a significant effect of position ($\beta = 0.15, SE = 0.14, p < .001$) but no effect of item type. The main effect of position arose because, regardless of whether the pseudoword sounded typical or atypical, children used the most common spelling significantly more often when the target was at the beginning of a pseudoword than when it was at the end.

Discussion

The findings show that phonotactic cues that induce the classification of a word as typical or atypical had a significant effect on the spelling choices of adults. Specifically, adults were more likely to write target phonemes with their most common spellings when the phonemes occurred in typical-sounding than in atypical-sounding pseudowords. This result suggests that adults' choice among alternative spellings for phonemes can be conditioned by whether they classify the item in which the phoneme occurs as part of the basic English vocabulary or as an atypical item which may be perceived as a foreign borrowing.

In contrast, the typicality of the pseudowords had no significant effect on the spelling of children in Grades 5 and 6. Previous studies suggest that children as young as in Grades 2 and 4 have some sensitivity to the phonotactic typicality of

spoken pseudowords (Treiman, Kessler, Knewasser, Tincoff, & Bowman, 2000). Thus, it is possible that the children tested here recognised that some items sounded more typical of English than others. However, the children may not have known that this might be relevant to choosing among alternative spellings of phonemes, or how it might be relevant. A subsidiary finding is that children used the most common spelling more often when the target phoneme was at the beginning of an item than when it was at the end. This finding is consistent with the report of Hayes et al. (2006) that children make less use of sublexical context than adults in determining whether to extend a final consonant.

Experiment 3

The goal of Experiment 3 was to seek converging evidence for the central finding of Experiment 2: that adults were significantly more likely to write common spellings for target sounds in pseudowords that seemed like typical English words than in pseudowords that seemed atypical. To do so, we used a spelling choice task rather than a spelling production task as in Experiment 2. The spelling choice task draws attention to *graphotactics*, that is, the typicality of the items' letter sequences, as well as phonotactics, the typicality of the phoneme sequences in the spoken items. Each pseudoword was written in two ways, one with the target phoneme written with the most common spelling and the other with a less common spelling. We asked participants to select the spelling that they considered most appropriate for the pseudoword.

Method

Participants

Forty undergraduates (10 male) from the University of Tasmania completed this study as part of a psychology class. None had participated in Experiments 1 or 2. Participants' mean age was 24 years ($SD = 6.6$), and all had English as a first language.

Materials and procedure

Participants were tested in two sessions of about 20 min each, in two groups of about twenty. In the first session, the experimenter read the same 64 pseudowords as used in Experiment 2, pronouncing each one three times. Participants were asked to repeat each item aloud to ensure that they had heard it accurately. Although the researcher (the first author) was not able to hear each participant's pronunciation as clearly as in an individual situation, she paid close attention to ensuring that everyone joined in, and asked for re-pronunciations when any participant stumbled over an item. The two groups each heard the pseudowords in a different order.

Participants each had a sheet that showed two alternative spellings for each pseudoword. These differed only in whether the spelling of the target phoneme was written with the most common spelling or a less common spelling. In each case, the less common spelling was the first (or only) of the less common spellings shown in Table 3. For example, the alternatives for /krʌsp/ were *crusp* and *krusp*. After participants had heard a pseudoword three times and repeated it, they were asked to circle the spelling that they considered to be the better spelling of that “new word.”

Results

Table 5 shows the mean proportion of times that participants chose the pseudoword that contained the most common spelling for the target sound. In both word-initial and word-final position, adults selected the option with most common spelling more often for typical- than atypical-sounding pseudowords. Also, participants were more likely to choose the option with the most common spelling for final than initial targets. These impressions were confirmed by a mixed-model analysis that was carried out at the trial level. The model included random intercepts for each participant and item pair, random slopes for participants as a function of item type and position, and random slopes for item pairs as a function of item type. The fixed factors were item type and position of the target. There was a significant effect of item type ($\beta = 0.56$, $SE = 0.15$, $p < .001$) such that participants were more likely to choose the most common spelling of the target sound when the nonword was typical than atypical. There was also a significant effect of position ($\beta = 1.65$, $SE = 0.27$, $p < .001$) such that choices of the most common spelling were more common for final targets than initial targets. Although the effect of item type appeared to be larger for initial targets than for final targets, a model that included the interaction between item type and position did not account for significantly more variance than the model that did not include the interaction ($p = .60$). Participants were significantly more likely to choose the alternative that contained the most common spelling than the other alternative for word-final targets and for word-initial targets in typical items ($ps < .001$ according to two-tailed binomial tests). The difference did not reach significance for word-initial targets in atypical items ($p = .09$).

Discussion

In this third experiment, we extended our testing paradigm from a spelling production task to a spelling choice task. As in Experiment 2, adults were more likely to choose more common spellings for target sounds in pseudowords that

Table 5 Mean proportion of choices in Experiment 3 containing most common spelling of target

Target position	Type of item	
	Typical (<i>SD</i>)	Atypical (<i>SD</i>)
Initial	0.68 (0.15)	0.55 (0.16)
Final	0.88 (0.12)	0.83 (0.15)

sounded like typical English words than for the same target sounds in atypical-sounding pseudowords. These findings provide converging evidence that inferred lexical classification, in this experiment provided by unusual graphotactics as well as unusual phonotactics, can influence adults' choices among spelling alternatives. They also help us to address a possible alternative explanation for the results of Experiment 2: that those participants showed an elevated rate of uncommon spellings for target sounds in atypical items only because they put so much effort into spelling the phonotactically unusual parts of these items that they were more haphazard in their spellings of the other sounds, including the targets. The fact that we obtained a difference between typical and atypical items in a spelling choice task, which is cognitively less demanding than the spelling production task of Experiment 2, speaks against this explanation.

Although there was no effect of position on adults' spelling of target phonemes in Experiment 2, the adults in Experiment 3 chose the most common spelling significantly more often for word-final than word-initial targets. This effect may stem from the fact that, in word-final position, the option that included the less common spelling looked quite deviant. For example, *plik* deviates from common English graphotactic patterns related to consonant extension. In initial position, the option that included the less common spelling, such as *phasp*, may not have looked as deviant. Although visual presentation of the spelling options affected the results in some ways, it did not change the central finding. This is that participants who heard items containing unusual sequences appeared to classify them as atypical and were more likely to select uncommon spelling options for the phonemes within them.

General discussion

In English, and in many other languages, some sounds have more than one possible spelling. Previous studies suggest that people's choices among the spelling options are conditioned by sublexical factors (Hayes et al., 2006; Treiman et al., 2002; Treiman & Kessler, 2006). The aim of the three experiments reported here was to investigate whether adults' and children's choices of spellings for phonemes in pseudowords would also be affected by their classifications of the items as a whole. In particular, do people classify some pseudowords as atypical, originating from a different language, and hence use less common spelling-to-sound correspondences for the phonemes within them? This is an important question given that English includes many words from other languages and given that the spellings of these words sometimes reflect their origins. The existence of such words has been noted by several linguists who have described the English spelling system (Albrow, 1972; Carney, 1994). To our knowledge, however, no behavioral research has systematically addressed the question of whether spellers implicitly classify some items as atypical and whether this classification affects their spelling choices. We did so by presenting participants with pseudowords, varying the way in which the pseudowords were described in the instructions (Experiment 1) and manipulating

the extent to which they sounded and looked like typical English words (Experiments 2 and 3).

Varying the instructions by telling participants that pseudowords were real but infrequent English words, words that had been made up by the experimenter, or the names of crazy monsters did not influence their choice of spellings. Across the three instruction conditions, children in Grade 2–3 and 5–6 and adults used near-identical proportions of the most common spellings of the target phonemes. These findings suggest that lexical classification is not influenced by manipulations to the instructions of the sort that have been used in previous studies. The reassuring implication is that, within this range, spelling researchers can continue to provide the instructions that are most engaging for their participants.

Varying the nature of the pseudowords themselves did influence the spelling of the adults in Experiment 2 and 3. These participants were more likely to choose a common spelling option for a target phoneme when it was part of a pseudoword that contained sequences that are common in English than when it was part of a pseudoword that contained very uncommon sequences. This was true whether participants only heard and wrote the items (Experiment 2) or also saw and chose their spellings (Experiment 3). Whereas adults showed an overall preference for the most common spellings of the target phonemes, this preference was attenuated when the pseudoword could be classified as atypical. The findings thus suggest that adults implicitly classify certain items as atypical and modify their spelling choices accordingly.

For children in Grades 5 and 6, the choice among spelling options for a target phoneme was not influenced by the typicality of the pseudoword in which it appeared. Evidently, it can take some years to learn how choices among alternative spellings of a phoneme may differ for words that are native to English and words originating from other languages. Sensitivity to sublexical conditioning of sound-to-spelling correspondences can take time to develop (Hayes et al., 2006; Treiman et al., 2002; Treiman & Kessler, 2006), and the same appears to be true for lexical conditioning.

We have attributed the effects shown by adults in Experiments 2 and 3 to classification: characteristics of a pseudoword as a whole lead participants to categorize it as a native English word that is likely to have common spelling patterns or as a word borrowed from another language, one that may have unusual spelling patterns. An alternative explanation is that these effects are sublexical, reflecting the influence of, for example, initial /bw/ on the spelling of final /f/. Because sequences like /bw/ are so rare, however, people would have little opportunity to learn about sublexical conditioning of this sort. We believe that lexical classification is a more plausible explanation, one that can unify the effects observed here and other cases of lexical conditioning of spelling (e.g., Mitchell et al., 2011; Pacton et al., 2005). Further research will be required to address this issue, as well as to examine possible effects of lexical classification on people's choices among alternative pronunciations of letters when reading (see Treiman, Kessler, & Evans, 2007, for a start on the latter).

Although questions remain, the present results call attention to the fact that, when a phoneme has more than one possible spelling, people do not choose randomly among the options. Rather, their choices are conditioned by both sublexical and lexical factors. One lexical factor that seems to affect the spelling performance of English-speaking adults, although not children, is the perceived origin of a word. Adults who are presented with items that have unusual sound patterns appear to classify them as atypical and to use less common spellings for the phonemes within them.

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Appendix: Spelling items used in experiments

Experiment 1

List 1 /'ʃiɡəs/, /'ʃeləp/, /'wufɛks/, /'wɪnək/, /'zelkəʊs/, /'zæθə/, /'sɛfrəd/, /sə'bul/, /'gæraɪb/, /'gɛpɒnt/, /'həʊti/, /'hʊbəm/, /'fævək/, /'fɪmɒʃ/, /'kɜmaɪd/, /'kɒlɪt/, /'rɪlkəm/, /'raɪkəb/, /'nəpəl/, /'nəbɪd/

List 2 /'ʃænəks/, /'ʃɪklən/, /'wɛmpət/, /'wɪbləʊ, /'zæbɪk/, /'zɪmət/, /'sɪldən/, /sə'roub/, /'gɛmbəʊs, /'gætni/, /'hɒflət/, /'hʊmɒp/, /'fæpni/, /'frɛləp/, /'kɜpəm/, /'krouɡət/, /'rɛθəm/, /'raɪgɒks/, /'nəbɒk/, /'naɪbət/

List 3 /'ʃæpwɒn/, /'ʃenəʊs/, /'wʊləd/, /'wɛpi/, /'zɪfəm/, /'zenθi/, /'sembi/, /'sɪdəʊn/, /'gæntəp/, /'gəməʊn/, /'hɒʃənt/, /'hʊkɪwəl/, /'fɪkməl/, /'frɛɪstæf/, /'kɒnəd/, /'kraɪkwɒn/, /'rɪnwɒl/, /'rɛmpɪ/, /'naɪzɛk/, /'nəkʊt/

Filler real words Adults: *motet, trestle, pithy, elfin*, children: *morsel, tassel, poncho, erode*

Filler pseudowords /'mɛfəl/, /'traɪbɒk/, /'præbəl/, /'ɪvɒp/, /'mɜnəm/, /'tələb/, /'pɪdwɒn/, /'ɛlɒpɒn/

Experiments 2 and 3

Initial target, typical /wɛsp/, /wɪlk/, /wɛmp/, /wæsk/, /krɒnt/, /kɒsp/, /klɛŋk/, /krɒsp/, /frɒntʃ/, /fæsp/, /fɪlt/, /fæmp/, /ʃɛnt/, /ʃɛlk/, /ʃɪŋk/, /ʃæmp/

Initial target, atypical /wɛʃp/, /wɪfk/, /wɛmv/, /wæsf/, /krɒnv/, /kɒfp/, /klɛʃk/, /krɒfp/, /frɒnv/, /fæθp/, /frɪz/, /fæmf/, /ʃɛnf/, /ʃɛlz/, /ʃɪfk/, /ʃæfp/

Final target, typical /glɛf/, /blɪf/, /brɒf/, /plɒf/, /brɛk/, /spɒk/, /stræk/, /plɪk/, /grætf/, /stɒtʃ/, /plɪʃ/, /prɛʃ/, /flɛl/, /twɛl/, /brɒl/, /prɪl/

Final target, atypical /ʃlɛf/, /bwɪf/, /vrɒf/, /pwɒf/, /bwɛk/, /ʃpɒk/, /sklæk/, /vlɪk/, /vrætf/, /sftɒʃ/, /ʃlɪʃ/, /pwɛtf/, /ʃlɛl/, /nwɛl/, /bwɒl/, /zrɪl/

IPA symbols used in spelling items and examples of each phoneme from Australian English

IPA	Example	IPA	Example	IPA	Example
Consonants					
p	<i>p</i> as in <i>pin</i>	f	<i>f</i> as in <i>fin</i>	h	<i>h</i> as in <i>hit</i>
b	<i>b</i> as in <i>bin</i>	v	<i>v</i> as in <i>van</i>	m	<i>m</i> as in <i>met</i>
t	<i>t</i> as in <i>tin</i>	θ	<i>th</i> as in <i>thin</i>	n	<i>n</i> as in <i>net</i>
d	<i>d</i> as in <i>din</i>	s	<i>s</i> as in <i>sin</i>	l	<i>l</i> as in <i>let</i>
tʃ	<i>ch</i> as in <i>chin</i>	z	<i>z</i> as in <i>zone</i>	r	<i>r</i> as in <i>rot</i>
k	<i>k</i> as in <i>kin</i>	ʃ	<i>sh</i> as in <i>shin</i>	w	<i>w</i> as in <i>wet</i>
g	<i>g</i> as in <i>gone</i>	ʒ	<i>s</i> as in <i>vision</i>		
Vowels					
æ	<i>a</i> as in <i>pat</i>	ɪ	<i>i</i> as in <i>pit</i>	ʌ	<i>u</i> as in <i>pun</i>
ɑ	<i>a</i> as in <i>part</i>	i	<i>i</i> as in <i>peat</i>	ʊ	<i>u</i> as in <i>put</i>
ɒ	<i>o</i> as in <i>pot</i>	eɪ	<i>a</i> as in <i>plate</i>	u	<i>oo</i> as in <i>spoon</i>
ɔ	<i>or</i> as in <i>port</i>	ɛ	<i>e</i> as in <i>pet</i>	aɪ	<i>i</i> as in <i>pine</i>
ə	<i>a</i> as in <i>about</i>	ɜ	<i>er</i> as in <i>pert</i>	oʊ	<i>o</i> as in <i>post</i>

For full IPA symbol list, see <https://www.internationalphoneticassociation.org/content/ipa-chart>

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