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Learning to spell and learning phonology: the spelling of consonant clusters in Kiswahili

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Abstract In orthographies studied to date, children learning to spell tend to omit one consonant of a cluster—for initial clusters, the second consonant, and for medial nasal clusters, the nasal. Explanations have included a special status for the initial consonant of a word, and the fact that in English nasal clusters are not true clusters but consist of a nasalised vowel plus a consonant. We tested children's spelling of initial and medial clusters consisting of a nasal consonant followed by another consonant, but non-nasalised vowels, in Kiswahili. For both initial and medial clusters, the nasal was spelled wrongly more often than the other consonant. The initial position in a word does not seem to have special properties. Rather, the spelling of clusters seems to depend on the properties of the individual phonemes, nasals being particularly difficult to spell. It is concluded that cross-linguistic studies of spelling development are necessary to draw generalised conclusions about phonological processing.

Keywords Spelling development · Kiswahili · Phonological development · Consonant clusters

Introduction

Learning to spell is more difficult than learning to read. It is often found that children can read words that they cannot spell (Frith, 1985). Spelling tasks seem to reveal more about a child's phonological knowledge than is possible with reading tasks. This has been found to hold for both fairly non-transparent

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languages, such as English, and for more regularly spelled languages such as Spanish or Portuguese (Bryant, Nunes, & Aidinis, 1999; Treiman, 1998).

Children's difficulties with spelling are not necessarily due to inadequate phonological knowledge. In some cases their phonological knowledge may be more accurate than that of adults. For example, they may spell ''stick'' as SDIK[1], indicating that they realise the second consonant is not the same as the initial consonant in ''tick''. In addition, when asked to count the number of sounds in words children can be more accurate than adults—indicating, for example, that they realise that ''my'' has one consonant and two vowel sounds, despite being spelled with only one vowel sound; adults usually count this word as having two sounds (Treiman, 1993, 1998; Treiman & Cassar, 1997).

In addition, when children's errors are pointed out to them, some will change their spellings but many will not. A common error is spelling words with initial consonant clusters (such as ''play'') with only the first of the two consonants (e.g., as PAY). When this error is pointed out, and children are asked what the difference is, they will frequently say that the words sound different to each other, and that the difference is in the region of the /p/, but that they are still spelled the same (Treiman, 1991).

In many languages children need to integrate phonological, orthographic, lexical and grammatical knowledge in order to become accomplished spellers. For example, the same sound can be spelled in different ways depending on its grammatical function; in English children must learn that the /nd/ sound in ''hand'' and ''tanned'' has a different grammatical function and hence is spelled differently (Treiman & Cassar, 1996). The same phenomenon can be seen in regularly spelled languages, such as Portuguese (Bryant et al., 1999).

One particularly interesting set of errors found in beginning spellers is the tendency to represent consonant clusters by using only one of the consonants. In English word-initial or syllable-initial clusters are usually stop-liquid (as in ''play'') or fricative-other consonant (as in ''smell'', ''fly'' or ''step''). In syllable-final clusters a nasal or liquid often appears first, before the stop or fricative (as in ''paunch'' or ''curt'') although again clusters with a fricative followed by a stop are found (as in ''past'', ''laughed''). In word- or syllable-initial consonant clusters in English, children tend to omit the second of the consonants, as discussed above. However, when word- or syllable-final clusters that start with nasals or liquids are examined, it is the first of the two consonants that is usually omitted. Hence children are likely to spell ''star'' as SAR but to spell ''sand'' as SAD (Treiman & Bourassa, 2000).

It has been suggested that the difficulty with syllable-final clusters that have a nasal-other consonant pattern stems from the fact that in these clusters in English, the vowel is nasalised. Children may therefore believe that the nasal consonant is adequately represented by the presence of the grapheme

[1] In this paper, the correct forms of English words are written in plain text, with double inverted commas (''stick''), the spellings of all words or phonemes in all languages, correct and incorrect, are written in capitals (SDIK), single phonemes and other phonemic transcriptions of words are notated between slash characters (/s/) and non-English words are notated in italics, with an English translation following in plain text (*panda*, ''climb'').

representing the vowel, and is not in fact a consonant at all. Evidence for this includes the finding that children, when asked the difference between the words ''bent'' and ''bet'', tend to indicate the vowel as the site of difference (Read, 1975). In addition Treiman, Zukowski, and Richmond-Welty (1995) found that children who are learning to spell French, which has strongly nasalised vowels, are specifically instructed to write nasalised vowels as vowel + nasal consonant (e.g., to spell ''bon'', /bõ/, as BON). These children are more successful at spelling such words when their overall spelling level is no better than children learning to spell English, who are given no such instruction. Children who are learning to spell Dutch make the same kind of errors as beginning English spellers, omitting the nasal in a syllable-final nasal-other consonant cluster. In addition, when asked to segment a CVCC word, they tend to give an answer that implies they have represented the word as CVC (van Bon & Uit-De-Haag, 1997). However, better Dutch spellers appear to improve in the spelling of such words (spelling them as CVCC) without improving on the segmentation (continuing to segment them as CVC). These authors suggest that better spellers still conceptualise the word as having a CVC structure with a nasalised vowel, but like French children they have realised that in spelling this is represented by letters corresponding to CVCC.

Rationale for the current study

This phenomenon in spelling development and these hypotheses about its origin are very interesting in that they enable us to examine children's ideas about the phonology of their language. However, given the lack of non-nasalised vowels preceding such consonant clusters in English it is difficult to test these hypotheses directly. Neither are word-initial clusters helpful in English, as they tend to involve a fricative followed by a stop, liquid or nasal or a stop followed by a liquid or nasal. Since in initial clusters the second consonant is usually omitted, it is possible that hypothetical initial clusters with a nasal followed by another consonant would be misspelled in the same way. Indeed, it has been hypothesised that word-initial clusters must always be treated like this by beginning spellers, as the second consonant is intrinsically more difficult to represent (Stemberger & Treiman, 1986). It is possible, however, that features of nasal consonants themselves, such as an intrinsic difficulty in their representation, are what makes them difficult to spell. We can look to another, non-European, language—Kiswahili—to find clusters that vary along dimensions that will help us to answer these questions.

Kiswahili and its phonology

Kiswahili is a language of the Bantu group spoken in areas of East Africa, particularly Tanzania and Kenya. It is used as the medium of primary education in most regions of Tanzania, is taught in schools in Kenya and Uganda and is a trade language in a wider area of East Africa. Use as a first language is limited to coastal and island areas of Tanzania and Kenya, although increasingly it is spoken in conjunction with other local languages in major conurbations in Tanzania.

In the early part of the 20th century, a colonial committee transcribed the language with the intention of having regular spelling (Inter-territorial Language (Swahili) Committee to the East African Dependencies, 1956). For the most part this has been achieved, and it is possible to read the language using one-to-one simple grapheme–phoneme correspondences, with a few digraphs but without any additional orthographic knowledge. There are only five vowels in Kiswahili, and the consonants are represented by those in the Roman alphabet (minus X and Q) plus the digraphs CH, DH, GH, KH, SH and TH.

Despite the complex morphophonemics of the language, generally the phonological realisation of a grammatical morpheme and its graphemic realisation correspond. For example, nouns in Kiswahili have grammatical prefixes. The prefix /m/ can indicate that a noun is animate. Before a vowel its phonetic realisation changes to /mw/. This is reflected in the spelling, as follows:

mnene	"fat person"
mwembamba	"thin person"

There are some dialectal, orthographic and grammatical features of the dialect of Kiswahili spoken in the study area which present particular difficulties for beginning spellers. Previous work on the language (Alcock et al., 2000) has shown that children learning to read Kiswahili display the typical pattern for learning to read a regularly spelled language, in that they can decode all words—including those they do not comprehend—once they have grasped the grapheme-phoneme correspondences. However, as in other regularly spelled languages, spelling does not display this all-or-nothing characteristic (Alcock & Ngorosho, 2003). Children make a variety of types of error, including errors based on dialectical features, and some errors in nasal clusters are seen. In addition, children are able to use grammatical knowledge in their attempt to disambiguate phonemes that sound similar but are spelled differently depending on context. This pattern—rapid development of reading skill but gradual spelling skill development based on use of a variety of information—is similar to the pattern found in other regularly spelled languages (Bryant et al., 1999). This paper will concentrate on phonological features of the language which are interesting because of their difference from previously studied languages.

Syllables in Kiswahili are almost exclusively open syllables (ending in a vowel), and there are few consonant clusters. As discussed above, previous work on learning to spell has suggested that, as well as the kind of interactions between grammatical and orthographic knowledge described in Alcock and Ngorosho (2003), the spelling of consonant clusters is particularly problematic (Treiman et al., 1995).

Although other types of consonant clusters are rare in Kiswahili, consonant clusters with a nasal as the first consonant are common. In English these clusters can only be found in a word-internal, syllable-final position. In Kiswahili, since virtually all syllables are open syllables, such consonant clusters are always syllable-initial (such as *ba-nda*, ‘‘shed’’) or including word-initial clusters (such as *ndi-mu*, ‘‘lime’’). In addition, the nasals can be syllabic or non-syllabic, depending on a variety of factors.[2]. Syllabic consonants, like /l/ in ‘‘bottle’’, do not have a full vowel, but consist of a single consonant pronounced as a syllable.

This study aims to utilise these unique features of consonant clusters in Kiswahili to investigate further the spelling of consonant clusters that include nasals by beginning spellers. Previous work finding that nasals are difficult to spell in word-final consonant clusters suggests this may be because children think they are part of the preceding vowel (Treiman et al., 1995), and that the first consonant of a word-initial consonant cluster has a special status which causes the second consonant of these clusters to be dropped preferentially (Stemberger & Treiman, 1986).

We hypothesise in contrast that the difficulty which beginning spellers experience with nasal consonants in particular (and, by extension, with consonant clusters in general) is due not solely to features of the surrounding phonemes in words but rather also to specific problems with nasals, especially their low phonetic salience and distinguishability compared to other consonants (Keller, 1994; Massaro & Cohen, 1995). We predict that nasals in clusters will be harder to spell than single nasals (prediction 1), and harder than the other consonant in these clusters (2), and further that this will apply both to word-initial and to word-medial consonant clusters (3). This study will therefore compare the spelling of nasal-other consonant clusters in different word positions, and with different degrees of salience.

Although the concept of salience has not been applied extensively to literacy research, a variety of acoustic, linguistic, and cognitive factors pertaining to words and sounds may be relevant here, and these can be termed ‘‘salience’’. Salient is therefore loosely defined as ‘‘acoustically or cognitively prominent’’. These factors are as follows.

Syllabic and *stressed* phoneme combinations are longer in duration and have greater amplitude, and this had been shown to affect, for example, second language acquisition of morphemes (Goldschneider & DeKeyser, 2001) as well as other aspects of language processing. In first language acquisition literature it has been suggested for some time that a word-final position causes children to pay more attention to a phoneme combination (Slobin, 1973), but the clusters used in this experiment cannot occur in this

[2] Technically the non-syllabic nasal-other consonant clusters consist of a pre-nasalised stop, fricative, or affricate; the main difference from English nasal-other consonant clusters is that they are syllable initial and that the nasal alters the quality of the second consonant itself, in the same syllable, rather than a vowel in a preceding syllable. Hence the nasals are genuinely part of the consonant cluster, not part of the vowel as in English and other European languages.The syllabic nasals are notated here interchangeably with a hyphen (e.g., *m-zazi*) and without (e.g., *mzazi*). In Kiswahili orthography the hyphen is not used but it is used here for clarity of comparison with non-syllabic nasals in the same position in the word

position. Classic research comparing initial and medial position in word strings leads to the conclusion that items in *initial position* are easier to remember (Glanzer & Cunitz, 1966). It has also been hypothesised that word-initial segments have a special status (Stemberger & Treiman, 1986), which may be based on sequential access of words (Frisch, 2000).

For these reasons the factors of syllabicity, stress, and position in the word are considered under the heading of "salience"; it is predicted that stressed clusters (4), those in initial position (5), and those that are syllabic (6) will be easier to spell than those that are unstressed, in medial position, or non-syllabic.

Features of Kiswahili nasals, and predictions which follow, are shown in Table 1.

As a consequence of the larger working memory load involved in remembering longer words to be spelled, it is also predicted that longer words will be harder to spell (7).

Table 1 Features of Kiswahili nasals and predictions arising from these

Feature	Example of first type	Example of second type	Prediction
Nasals can occur both in clusters and singly	*panda* ("climb")	*tena* ("again")	1: Nasals in clusters will be harder to spell than single nasals
Clusters consist of a nasal followed by another consonant	N in *panda*	D in *panda*	2: Nasals in clusters will be harder to spell than other consonants in clusters
Clusters can occur in both word-initial and word-medial positions	*ngazi* ("stairs")	*tundika* ("to hang up")	3: Errors will occur on the nasal rather than the other consonant in both word-initial and word-medial consonants
	bamvua ("to take apart")	*mbeleko* ("baby sling")	4: Nasals in clusters in the middle of words will be harder to spell than those at the beginning of a word
Clusters can occur in either unstressed or stressed syllables. The penultimate syllable is always stressed in Kiswahili	*nguruwe* ("pig")	*mvua* ("rain")	5: Unstressed nasals in clusters will be harder to spell than stressed nasals in clusters
Clusters can contain either a non-syllabic nasal or a syllabic nasal. Syllabicity depends on grammatical features of the word, and all possible nasals (/n/, /ŋ/ and /m/) occur in clusters in both syllabic and non-syllabic form, with equivalent grammatical function	*nzuri* n-zuri adjective prefix 9—good	*mzuri* m-zuri adjective prefix 1—good	6: Non-syllabic nasals in clusters will be harder to spell than syllabic nasals in clusters

In addition to predictions made about errors involving omission or substitution of an existing nasal consonant, it is also predicted (8) that errors will be made that involve the addition of nasals to words that should not contain them. Children will be more likely to add nasals in contexts where a nasal can occur, and likewise will be more likely to add nasals where less salient nasals (as defined above) could occur.

Finally it is predicted (9) that children who are older and/or have had more education will improve in their spelling accuracy, but this will be disproportionately due to improved spelling of difficult patterns, in this case clusters. For this reason children were tested who were in two different school grades, and within these grades of a variety of ages (one school grade in this school system encompasses a wide age range). Piloting and previous studies (Jukes et al., 2002) revealed that among children in first and second grades there were large numbers of children whose spelling was unscoreable and so children in the third and fourth grades were chosen.

Experiment 1

Materials

Table 2 shows the groups of words used, including the characteristics of the words (containing a nasal or not, containing a nasal cluster or not) and the nasals (in a stressed or unstressed syllable, initial or medial, syllabic or non-syllabic), an example word, its English translation, the number of syllables, and the number of words of that type in the stimulus set.

Experiment 1 therefore compares three experimental groups of words, containing medial and initial non-syllabic nasal clusters (groups E1 and E2), and initial, unstressed, syllabic nasal clusters (group E3). These are further compared with two control groups of words, which have no nasal clusters (groups C1 and C2). Ten words were used in each of the groups.

Table 2 Examples of stimuli used in Experiment 1

Group	Nasal	Cluster	Position	Syllabic	Stressed	Syllables	No of words	Example
Control group 1	N	–	–	–	–	2 3	5 5	*bata* (“duck”) *pikia* (“cook for”)
Control group 2	Y	N	Medial	N	N	2	10	*pima* (“measure”)
Experimental group 1	Y	Y	Medial	N	Y	3	10	*andazi* (“doughnut)
Experimental group 2	Y	Y	Initial	N	Y N	2 3	5 5	*mbili* (“two”) *Nguruwe* (“pig”)
Experimental group 3	Y	Y	Initial	Y	N	3	10	*Mzazi* (“parent”)

In choosing these words, the more difficult dialect and grammatical spelling issues were generally avoided, avoiding for the most part words with two adjacent identical vowels, words with H or L/R difficulties, and words with TH or DH (Alcock & Ngorosho, 2003). In any case, errors of these types were not scored.

Frequency counts are not available for Kiswahili, and neither are standardised reading or spelling tests. However, children are introduced to the written form of a word almost exclusively through their school grade-level reading books, and these should give some indication of how difficult a word might be to read or how frequently a child might encounter the spoken form. Both Tanzania and Kenya have national Kiswahili reading books but the Kenyan Institute of Education has rewritten their books more recently and they are constructed on more principled lines than the Tanzanian books, so these books were chosen to determine the reading difficulty of each word. The grade level of each word was taken to be the first reading book in which the word is encountered. A Chi-square analysis revealed no difference between the grade level of words in each of the groups of words.

Participants

A total of 93 children, from schools A and B, who had all been tested for a previous study (Alcock & Ngorosho, 2003) were tested for Experiment 1. They were tested in March, 2 months into the school year, and were in third and fourth grade; all children who had taken part in the previous experiment, and who were present on the day of testing, were tested. The children were aged 10–15 years (a normal age range for these grades in rural sub-Saharan African schools; mean 12.8 years, *SD* 1.20).

Methods

All children had previously been tested using an adaptation of the Wide Range Achievement Test (WRAT Spelling, Jastak & Wilkinson, 1984), which is described in Alcock and Ngorosho (2003), and was used as part of a larger study (Jukes et al., 2002). All children who were present were also retested on the WRAT adaptation in July or August of the year of the study. Hence all children were accustomed to this form of spelling test. The same method was used as in the previous study, children being tested in groups of 15–20, with a tester reading each word, followed by a context sentence, followed by the word again. Children were encouraged to write what they could, and to write only the single word tested, and the tester checked during the test for copying and for children writing extraneous words.

All words were scored correct or incorrect, and incorrect words were categorised according to whether an error involving a nasal (whether changed, added, or omitted), an error involving the other consonant in the cluster, or another type of error was made.

Results and discussion

Overall error rates

The mean number correct for all 50 words (control and experimental) was 44.26 (*SD* 4.38) The range of total correct on this spelling test was 23–49, hence no child achieved a perfect score. The mean number correct on the 30 experimental words (those with clusters) was 25.9, which represents a mean error rate of 13.4%, after allowing for a few words which were not attempted.

Item analysis revealed that two words in the group of experimental words (*bamvua* and *nzuri*) had error scores which lay more than three standard deviations away from the mean. In order to ensure that any effects found were typical of the majority of experimental stimuli, analyses were carried out both with and without these two items only, and where the analyses differed, these are reported as analyses with ''all items'' or ''outliers removed''. Where both analyses gave the same result, the analyses given are those for all items.

Errors on words containing nasals and nasal clusters were analysed for errors involving either the nasal in the word or cluster, or the other consonant in the cluster. These errors were divided into ''omission'' errors or ''other'' errors (either substitution or duplication—duplication of a nasal in Kiswahili results in a difference in pronunciation, adding a syllable, so is not a phonologically neutral, orthographic error as it would be in other languages such as English). There were far more ''omission'' errors than ''other'' errors for nasals in clusters, but ''other'' errors appear to result from a similar failure to represent a consonant accurately, so these have been combined for the purposes of analysis. Examples of the error types are shown in Table 3.

All results in this paper are reported as follows: Analyses carried out on subjects individually, averaging across items: F_1, t_1 etc; analyses carried out on items individually, averaging across subjects: F_2, t_2 etc.[3] Effect sizes (Cohen's *d* or partial η^2 as appropriate) are reported, and where equal variances cannot be assumed, exact degrees of freedom are given for *t*.

Predictions 1–3—Nasals in clusters should be harder to spell than single nasals, and within clusters, nasals should be harder to spell than the other consonant; this should apply both to medial and initial clusters

The difference between the proportion of errors on single nasals and that on nasals in clusters was significant ($t_1(92) = 13.90$, $P < .001$, $d = .96$,

[3] It will be seen that in some cases the analysis by subjects shows a significant difference, where the analysis by items does not. This would seem to suggest that some items used may not be wholly typical of items in the language as a whole. In fact, this is not very surprising, as in both experiments in some item groups words have been used which are very frequent as tokens, being very common words in the language (such as *nje*, ''outside'' and *mvua*, ''rain''), but the phonological form of which is not very frequent among phonological forms in the language—short words such as these two-syllable words are less frequent in Kiswahili as a whole. See, for example, Nation and Snowling (1998), where using highly familiar words with beginning readers produced a similar pattern of significances.

Table 3 Proportion of errors on each type of consonant in nasal clusters

Type of word and group (from design table)	Proportion of omission of first (nasal) consonant	Other error on first (nasal) consonant	Omission of second (non-nasal) consonant	Other error on second (non-nasal) consonant	Proportion of words with nasal error
Medial nasal, not in cluster, e.g. *hema* Group C2	HEA .000	HENA .002	–	–	.002
Medial nasal cluster e.g. *sanduku* ** Group E1	SADUKU.015	SAMDUKU .000	SANUKU .001	SANTUKU .021	.015
Initial non-syllabic, stressed cluster e.g. *mvua* ** Group E2, 2 syllable	VUA .048	NVUA .016	MUA.002	MZUA .008	.064
Initial non-syllabic, non-stressed cluster e.g. *nguruwe* * Group E2, 3 syllable	GURUWE .037	MGURUWE .000	NURUWE .000	NDURUWE .017	.037
Initial syllabic, non-stressed cluster e.g. *mdudu* n.s. Group E3	DUDU .000	NDUDU .008	MUDU .002	MTUDU .012	.008

Significant results (indicated *, $P < .05$ or **, $P < .001$) are comparisons between all errors on the nasal consonant and all errors on the other consonant in the cluster. Where appropriate, proportions indicated are without outlier words

$t_2(29.46) = -2.62$, $P = .013$, $d = .68$, compare group C2 with groups E1-3 in Table 3). Nasals are harder to spell in clusters than they are singly. In words with single nasal consonants, there was no significant difference between the proportion of errors on the nasal consonants and that on the other consonants (group C2). Hence nasals are no harder than other consonants to spell when they are singly placed.

The error rates for the nasals and the other consonants in the nasal-other consonant clusters were compared. Overall error rates for nasals and other consonants in clusters in each type of word can be seen in Fig. 1; means are in Table 3. There were significantly more errors in nasals compared to the other consonant in such clusters ($t_1(92) = 14.28$, $P < .001$, $d = 1.025$, $t_2(29) = 2.26$, $P = .031$, $d = 0.588$).

Upon breaking down the words with nasals into different types, for each type of word there were significantly more errors on the nasal consonant than on the other consonant in the cluster, with the exception of the initial syllabic nasals (group E3). These data are summarised in Table 3 (groups E1-3), with the mean proportion of errors on single medial nasals included for comparison (group C2). In cases indicated as significant, analyses were significant for both subject analysis and item analysis, and whether outliers were included or excluded. This was true with the exceptions of (a) medial nasal clusters, where the comparison was only significant for the main subject analysis, and (b) initial nasal clusters in two-syllable words, where both subject comparisons were significant, but neither item analysis.

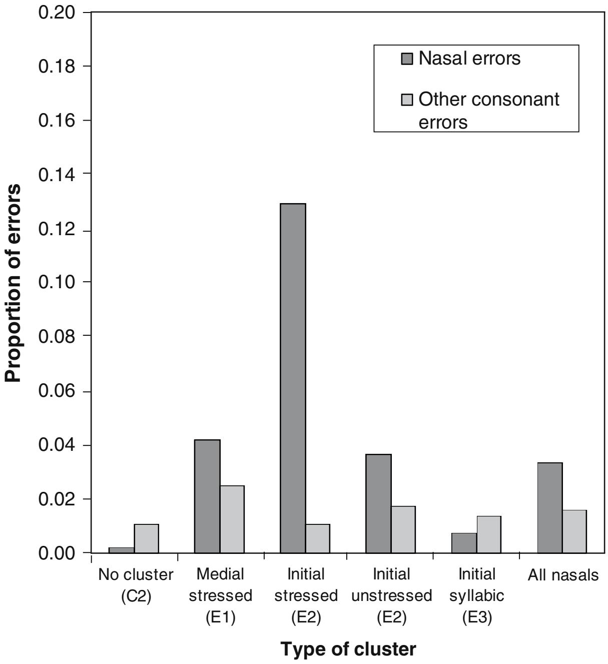


Fig. 1 Experiment 1: nasal and other consonant errors on words in different types of clusters

Summary for predictions 1–3

Hence we have confirmed that, in Kiswahili as in other languages, beginning spellers find the nasal consonant of a nasal-other consonant pair harder to spell, including for some word-initial clusters; nasals are also harder to spell in clusters than they are singly.

Predictions 4–6—effects of stress, position and syllabicity

As discussed above, some nasal clusters are word-medial and some word-initial, some are stressed and some unstressed, and these factors covary with word length, due to the invariable penultimate stress in Kiswahili words. As not all possible combinations of words are represented, it was necessary to carry out repeated *t*-tests on relevant pairs of conditions; the following *P* values are all corrected for multiple comparisons using the Bonferroni method. These comparisons investigate the predictions that stress and position in the word will affect spelling.

Predictions 4 and 5—stress, position in the word and their relation with word length

Examining word length and position but controlling for stress, the nasals in medial clusters (which are in three-syllable words and have a stressed nasal) were easier to spell than those nasals in initial clusters which were in two-syllable words and were also stressed ($t_1(92) = 5.65$, $P < .001$, $d = .71$, t_2 n.s., compare group E1 with two-syllable group E2 words in Table 3).

Examining stress and word length but controlling for position, unstressed nasals in initial clusters that were in three-syllable words were also easier than those in the stressed-initial-cluster nasals that were in two-syllable words ($t_1(65) = 6.097$, $P < .001$, $d = .66$, t_2 n.s., compare group E2 two- and three-syllable words in Table 3).

Examining position and stress but controlling for word length, medial stressed clusters were easier than initial unstressed nasal clusters in three-syllable words ($t_1(92) = -2.56$, $P = .012$, $d = .21$, $t_2(12) = 2.62$, $P = .022$, $d = 1.37$, both without outliers only, compare group E1 with three-syllable words in group E2).

Hence the length of a word affected its difficulty—in fact, the shorter words were harder to spell. Initial clusters were harder to spell, but whether a nasal cluster was stressed or not did not reliably affect its difficulty.

Summary for predictions 4 and 5

Looking at stress and position, findings have been mixed and somewhat counter-intuitive. Initial clusters and those that are stressed seem to be harder to spell, which appears to be related to—possibly a result of—the words with initial or stressed clusters also being the shorter words (compare two-syllable words in group E2, which have initial, stressed clusters to words in group E1, with medial clusters, and three-syllable group E3 words, with initial, unstressed clusters).

Prediction 6—syllabicity

In some words the nasal in an initial nasal cluster constitutes a syllable in itself (*m-dudu*, insect) and in others it is not syllabic (*nguruwe*, pig). The spelling of syllabic nasals in clusters (which are all initial, in three-syllable words, and unstressed) was compared to initial, non-syllabic nasals in clusters (compare group 4 to group 5 in Table 2). Half of the latter were in three-syllable words and were unstressed while half were in two-syllable words and were stressed.

Comparing to the non-syllabic nasals the syllabic nasals were significantly easier to spell ($t_1(92) = 6.07$, $P < .001$, $d = .90$, $t_2(17) = 2.39$, $P = .029$, $d = 1.07$, outliers excluded).

Summary for prediction 6

Here we confirmed our hypothesis that syllabicity would make nasals easier to spell.

Prediction 7—overall effect of word length

Overall, two-syllable words were easier to spell than three-syllable words ($t_1(92) = 6.59$, $P < .001$, $d = .658$, $t_2(2.61) = 43.80$, $P = .012$, $d = 0.721$ outliers removed).

Summary for prediction 7

Rather than confirming our prediction 7, that longer words would be more difficult to spell, shorter words were in fact more difficult to spell.

Additional analyses following predictions 1–7—phonetic density

Among non-syllabic nasals in clusters, the most difficult to spell were the two-syllable words, where the cluster is stressed and initial, although these clusters would seem to have higher saliency according to our definition. It was also predicted that shorter words would be easier to spell, but this was likewise disconfirmed. This may be because these words have a higher density of consonants. This was not hypothesised a priori, but is one possible factor which could make both shorter words and those with clusters harder to spell. The effect of phonetic density, calculated by taking the ratio of consonants to vowels in a word, on the difficulty of spelling nasals in consonant clusters was examined. This factor is not one that has been reported to be related to literacy or language acquisition in the past, so has been defined de novo for this paper, but on pragmatic grounds it seems worth investigating.

The ratio of consonants to vowels was found be significantly related to the number of errors on nasals in clusters ($F_1(2, 91) = 24.85$, $P < .001$, $\eta^2 = .12$,

F_2 n.s.). Planned comparisons revealed that the most errors were made in words with 1.5 consonants per vowel (all of which are two-syllable words with initial, stressed clusters), followed by words with 1 consonant per vowel (which could be two- or three-syllable words, and initial or medial clusters), followed by words with 1.33 consonants per vowel (which are all three-syllable words and can either have medial, stressed clusters or initial, unstressed clusters).

Summary for additional analyses

It is difficult to determine if the real difficulty with initial, stressed clusters in two-syllable words is due to higher phonetic density, but this finding is suggestive. More errors were made on words with 1.5 consonants per vowel than on either of the other density groups; this group includes words which might seem to have salient nasals—those with initial stressed nasal clusters—but which were more poorly spelled. The presence of a cluster in a shorter word—here, the words with the initial stressed clusters—hindered spelling more than in a longer word.

Prediction 8—adding nasals to words

Children also had a tendency to add nasals to words. These were more likely to be added in a word that already had a nasal ($t_1(92) = 3.61, P < .001, d = 0.45, t_2$ n.s.) and in a word that already had a nasal cluster ($t_1(92) = 3.32$, $P = .001$, $d = 0.46$, $t_2(33.07) = 2.96$, $P = .006$, $d = 0.78$). A oneway ANOVA comparing addition of nasals in four different contexts (within clusters, before unvoiced and voiced consonants, and before vowels) revealed that there was a significant difference between the number of nasals added in different within-word contexts ($F_1(3{,}90) = 5.19, P = .002, \eta^2 = .053, F_2(3, 47) = 2.71, P = .047, \eta^2 = .053$).

Planned comparisons showed that nasals were more likely to be added within existing nasal clusters than either before unvoiced consonants (mean difference = 0.15, SE = .04, $P = .004$) or vowels (mean difference = 0.13, SE = 0.46, $P = .040$); the difference between addition of nasals before voiced consonants and unvoiced consonants approached significance (mean difference = 0.24, SE = .093, $P = .079$).

Hence children were more likely to add nasal consonants in words that already have nasals and, indeed, already have nasal clusters, and they are more likely to add nasals to within-word contexts where there are already nasal clusters, or, in the case of before voiced consonants, where nasals are more likely to be found.

Apart from syllabic nasals, the appropriate nasal in a Kiswahili word depends on the following consonant: /m/ is allowed before labial consonants, /n/ before alveolar consonants and /ŋ/ before velar consonants. The latter two are both spelled N.

However children were less likely to add a nasal appropriate to the context than one that did not match the context ($t_1(92) = 2.75$, $P = .007$,

d = , $t_2(47) = 3.57$, $P = .001$, $d = 0.71$, in both analyses without outliers). This was because most of the nasals that were added were placed within existing clusters, and were different from the other nasal already in the cluster (e.g., *nzuri* spelled as MNZURI).

At the beginning of some words in some grammatical contexts, notably adjectives agreeing with nouns in some noun classes, a voiced consonant is obligatorily preceded by a nasal. Children were most likely to add a nasal before a voiced consonant even when the grammatical context did not demand it, or inside a cluster that already had a nasal consonant.

Almost all of the consonants added to words were nasals added next to other consonants. All errors involving adding consonants to form an initial cluster (either adding consonants to initial single consonants or to existing two-consonant clusters) were analysed. Adding consonants varied significantly by position (before vs. after another initial consonant vs. within an existing cluster ($F_1(2, 91) = 3.77$, $P = .02$, $\eta^2 = .039$, $F_2(2, 46) = 4.15$, $P = .019$, $\eta^2 = .081$ with outliers removed).

Summary for prediction 8

Our hypothesis that children will add nasals to clusters was also confirmed. Children displayed their knowledge about where it is appropriate to place a nasal consonant in their errors in adding consonants. They were likely to add nasals before a voiced consonant, in a position where in some contexts nasals are obligatory and also inside a pre-existing nasal-other consonant cluster.

Prediction 9—good and poor spellers

Although the hypothesised effects of grade or age on spelling scores were not found, children were divided into good and poor spellers (those who scored above or below the median score) and the effect of spelling skill on the spelling of different types of nasals was examined. This is shown in Fig. 2.

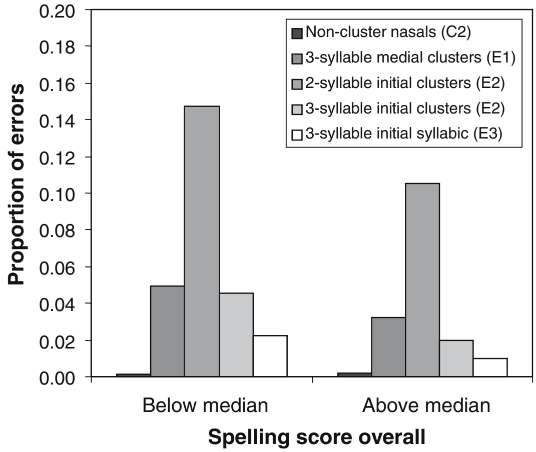
An ANOVA revealed a significant interaction between spelling skill and nasal errors on different types of word (non-cluster nasals, medial cluster nasals, initial cluster non-syllabic, and initial cluster nasals) ($F(3, 89) = 5.51$, $P = .001$, $\eta^2 = .057$).

Post-hoc comparisons revealed that the difference between good and poor spellers was only significant for the initial non-syllabic cluster nasals ($t(58.94) = 2.85$, $P = .006$, $d = .58$). This represents a difference selectively on the hardest phonological task.

Summary for prediction 9

Confirming our final hypothesis, better spellers improved selectively at spelling stressed, initial nasals in clusters—the type of cluster with very high phonetic density. They did not improve in spelling the easier syllabic, initial nasals in clusters, indicating that their success in extracting information about

Fig. 2 Experiment 1: nasal errors on different types of clusters by good and poor spellers



the individual phonemes from a phonetically challenging word is what enables them to spell better.

Implications of Experiment 1

In Experiment 1 most of the nasals in clusters were non-syllabic (those in groups E1 and E2). It is possible that, as in English, non-syllabic nasals in clusters are hard to spell because they are realised phonetically as the nasalised version of another phoneme. In the case of English this is the preceding vowel; in the case of Kiswahili this is the following consonant. However in Kiswahili syllabic nasals in clusters are not nasalised versions of another phoneme but are separate phonemes. Such syllabic nasals are not found in an equivalent position in English. These were used in Experiment 1 but only in one condition, so that syllabicity was confounded with the other variables investigated. To investigate further the spelling of nasals in clusters, Experiment 2 examines only syllabic nasal clusters, varying other factors.

Experiment 2

Hypotheses, design and materials

Experiment 2 compares the spelling of initial and medial, stressed and non-stressed, syllabic clusters. The two control and three experimental group of words used can be seen in Table 4.

Note here that group E3 (medial nasals) contains an uneven distribution between stressed (three-syllable) and unstressed (four-syllable) words. This is an inevitable result of the Kiswahili lexicon. These words must be verbs because nouns cannot have syllabic, medial nasals, and to have three-syllable verbs with medial nasals, the verb must have a one-syllable root, these verbs

Table 4 Design matrix for Experiment 2

Group	Nasal	Cluster	Position	Syllabic	Stressed	Syllables	No of words	Example
Group C1	N	–	–	–	–	2	4	*kaka* ("brother")
						3	3	*dawati* ("desk")
						4	3	*kupikia* ("to cook for")
Group C2	Y	N	Medial	N	N	2	5	*tena* ("again")
						3	5	*kuzima* ("to put out")
Group E1	Y	Y	Initial	Y	Y	2	10	*nta* ("wax")
Group E2	Y	Y	Initial	Y	Y	3	10	*mtoto* ("child")
Group E3	Y	Y	Medial	Y	Y	3	2	*kumpa* ("to give him/her")
					N	4	8	*kumpata* ("to get him/her)

having a one-syllable grammatical prefix in addition to the syllabic nasal. Kiswahili has very few one-syllable roots, and only two one-syllable verb roots, both of which are used here; these are both very common verbs (*-pa*, "give", and *-la*, "eat").

Note also that group C1 (words without nasals) has four two-syllable, three three-syllable and three four-syllable words. In Experiment 1 the equivalent group had five each of two-syllable and three-syllable words. However, in Experiment 1 there were no four-syllable words in any other category, but there are four-syllable words in Experiment 2's Group C3. This slightly uneven distribution of words without nasals is a best attempt at dividing 10 words by three in order to match the words without nasals as closely as possible in length to the words with nasals.

Again ease of spelling is hypothesised to be determined at least partly by saliency, defined as above. In this experiment this will be investigated using the following predictions concerning difficulty of spelling:

(1) Nasals in clusters will be more difficult to spell than nasals outside clusters since nasals outside clusters are more salient—this will lead to more errors on nasals in the experimental groups than those in group C2.

(2) Nasals will be more difficult to spell than other consonants when these are together in a cluster since nasals have lower saliency than other consonants. This will lead to more errors on the nasal than the other consonant in clusters in all three groups of experimental words.

(3) Nasals will be easier to spell when they are in stressed syllables, since stressed syllables are more salient—this will lead to more errors on nasals in clusters in group E2 and in the four-syllable words in group E3, than on words in group E1 and the three-syllable words in group E3.

(4) Nasals will be easier to spell when they are in initial position, since initial nasals are more salient—this will lead to more errors on nasals in groups E1 and E2 than in group E3.

In addition, following on from the results of in Experiment 1, the impact of phonetic density will be investigated. From the results in Experiment 1, it is predicted (prediction 5) that words with higher phonetic density will be harder to spell. Finally it is likewise predicted that children will add nasals to words, in particular in contexts that can plausibly have nasals (prediction 6) and that better or more experienced spellers will selectively improve at the harder types of words (prediction 7).

The words in this experiment also met the same criteria as in Experiment 1 (avoidance of sounds and their combinations that are difficult to spell, apart from the clusters) but in this case unvoiced consonants were also included as the second consonant in clusters, since these are permissible in syllabic nasal clusters.

Participants

A total of 43 children from schools C and D in the previous study (Alcock & Ngorosho, 2003) took part in Experiment 2, and were tested the year following initial participation, in July (5 months into the school year), when they were also in third and fourth grade. Again all children present on the day of testing who had done the WRAT adaptation in the previous study were tested on this task. Hence all children again were familiar with this style of spelling test. The children in this experiment were aged 11–15 years (mean 12.9 years, *SD* 1.23).

Methods

The same procedure was followed as for Experiment 1, and for the WRAT adaptation. Grade levels of words were determined from school reading books as in Experiment 1. Chi-square analysis again revealed no difference in grade level of the words in each of the groups of words (groups 1–5).

Results and discussion

Overall error rates

The mean number correct on this test was 43.73, which was not significantly different from the mean number correct on the WRAT adaptation (Alcock & Ngorosho, 2003) given later in the year. The mean correct on the 30 experimental words was 24.2, giving a mean error rate of 19.5%.

Performance overall by children in Experiment 2 and those in Experiment 1 was compared; there was no significant difference between total scores on the two spelling tests. In addition, performance on the words that were identical in Experiments 1 and 2 was compared. An ANOVA revealed no effect of the experiment that children were participating in, the grade that children were in, or the presence of a nasal in the word (all such words had no clusters).

Analysis of error frequency by words revealed one word for which the *z*-score of nasal errors was greater than 3.0, and analyses below were all redone with this one word omitted, as in Experiment 1 to ensure effects were general. Removal of outliers made no difference to any analysis in Experiment 2.

Effect of word length

In Experiment 1 it was hypothesised that shorter words would be easier to spell, but, counterintuitively, shorter words were in fact harder to spell. No prediction was therefore made about word length in Experiment 2, but it was nonetheless found that word length significantly affected the proportion of words spelled correctly ($F_1(2, 84) = 13.47$, $P < .001$, $\eta^2 = .24$, $F_2(2, 46) = 2.69$, $P = .078$, $\eta^2 = .105$). Longer words were in fact easier to spell. Planned comparisons revealed that the two-syllable words were harder than either of the other type of words (mean difference = 0.12, SE = 0.018, $P < .001$ for comparison between 2 and 3 syllable words; mean difference = 0.08, SE = 0.030, $P = .042$ for comparison between 2 and 4 syllable words), and that there were no differences between three- and four-syllable words.

Prediction 1—single nasals and those in clusters

As in Experiment 1, comparisons between nasals in clusters (all experimental word groups) and singly (group C2), and other consonants in clusters and singly were carried out. Nasals in clusters were significantly harder to spell than other nasals ($t_1(42) = 8.20$, $P < .001$, $d = 1.78$, $t_2(29.54) = 3.03$, $P = .005$, $d = 0.77$, compare group 2 with groups 3–5 in Table 4). However, stop consonants were no harder to spell in clusters than in words where they were only found singly.

Predictions 2–4—type of consonant, stress and position

When the errors in the nasal and the other consonants in the clusters were compared, across the stressed and unstressed and initial and medial clusters, main effects were found of stress ($F_1(1, 42) = 32.59$, $P < .001$, $\eta^2 = .43$, $F_2(1, 26) = 6.74$, $P = .015$, $\eta^2 = .21$), position in the word ($F_1(1, 42) = 6.55$, $P = .014$, $\eta^2 = .14$, F_2 n.s.) and the type of consonant ($F_1(1, 42) = 6.20$, $P = .017$, $\eta^2 = .12$, F_2 n.s.).

Hence consonants were harder to spell correctly when they were in stressed than unstressed clusters (in Table 4, compare group E1 and three-syllable words in group E3, with group E2 and four-syllable words in group E3), in initial position than in medial position (compare groups E1 and E2 with group E3), and nasal consonants in clusters were harder to spell than the other consonant in the cluster (see all experimental groups of words in Table 4).

Significant interactions were found between stress and position ($F_1(1, 42) = 14.37$, $P < .001$, $\eta^2 = .25$, F_2 n.s.), between stress and type of consonant ($F_1(1, 42) = 5.13$,

$P = .029$, $\eta^2 = .11$, F_2 n.s.), between position in the word and type of consonant ($F_1(1, 42) = 12.76$, $P = .001$, $\eta^2 = .23$, F_2 n.s.) as well as a three-way interaction between stress, type of consonant, and position in the word ($F_1(1, 42) = 18.56$, $P < .001$, $\eta^2 = .31$, $F_2(1, 26) = 4.10$, $P = .053$, $\eta^2 = .13$).

These patterns can be seen in Fig. 3.

Post-hoc comparisons revealed that there were more errors made on nasals in clusters that were initial and stressed than on any other type of nasal (comparison with initial and unstressed $t_1(42) = 9.62$, $P < .001$, $d = 1.98$, $t_2(9.05) = 3.19$, $P = .011$, $d = 1.43$, comparison with medial stressed nasals $t_1(42) = 5.80$, $P < .001$, $d = 1.193$, $t_2(9.61) = 2.61$, $P = .026$, $d = 1.19$, comparison with medial unstressed nasals $t_1(42) = 5.40$, $P < .001$, $d = 1.21$, $t_2(9.13) = 2.99$, $P = .015$, $d = 1.35$), while differences between other types of nasals in clusters were not significant.

The proportions of different types of errors in different types of words can be seen in Table 5.

Summary for predictions 2–4

Initial, stressed clusters were the hardest to spell; the difficulty with stressed clusters was greater for the nasal in the cluster than for the other consonant; and the difficulty with initial clusters was also greater for the nasal than for the other consonant. Finally the particular difficulty with initial, stressed clusters only applied to the nasal consonant in the cluster; for the other consonant in the cluster, there was more difficulty with stressed medial clusters. This particular difficulty with nasals in initial clusters was also found in Experiment 1, even though in Experiment 2 nasals in all such clusters were syllabic.

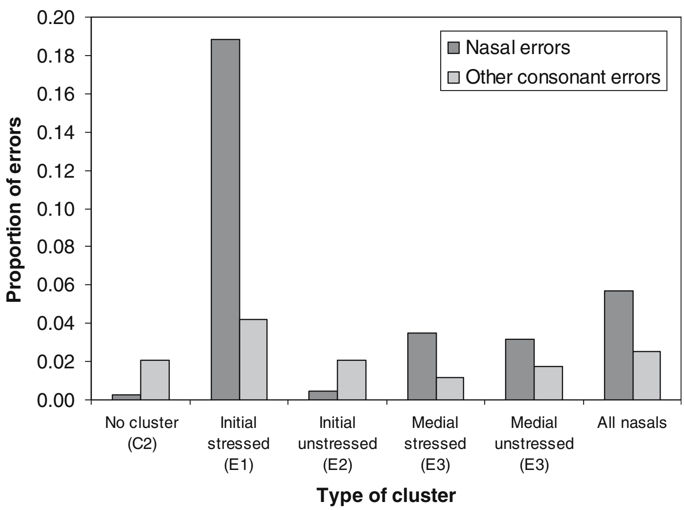


Fig. 3 Experiment 2: nasal and other consonant errors on words in different types of clusters

Table 5 Frequency of nasal and other errors in each type of word

Type of word and group (from design table)	Proportion of omission of first (nasal) consonant	Other error on first (nasal) consonant	Omission of second (non-nasal) consonant	Other error on second (non-nasal) consonant	Proportion of words with nasal error
Medial nasal, not in cluster e.g. *kuvuna* Group C2	KUVUA .000	KUVUMA .002	–	–	.002
Initial nasal in stressed cluster e.g. *mvi* ** Group E1	VI .005	NVI .184	MI .007	MZI .014	.189
Initial nasal in unstressed cluster e.g. *mtoto* n.s. Group E2	TOTO .000	NTOTO .005	MOTO .005	MDOTO .019	.005
Medial nasal in stressed cluster e.g. *kumla* n.s. Group E3	KULA .012	KUNLA .023	KUMA .000	KUMRA .012	.033
Medial nasal in unstressed cluster e.g. *kumcheka* n.s. Group E3	KUCHEKA .032	KUNCHEKA .000	KUMEKA .000	KUMSHEKA .015	.032

Significant results (indicated *, $P < .05$ or ** $P < .001$) are comparisons between all errors on the nasal consonant and all errors on the other consonant in the cluster, main subject analysis.

Prediction 5—phonetic density

Words which are shorter have a higher concentration of consonants, even where words with clusters are compared with each other. The number of consonants per vowel was calculated and the proportion of nasal errors was found to be significantly related to the number of consonants per vowel ($F_1(4, 39) = 18.29$, $P < .001$, $\eta^2 = 0.30$, $F_2(4, 25) = 3.04$, $P = .036$, $\eta^2 = .32$). The word on which children made the most nasal errors had three consonants per vowel.

These data can be seen in Fig. 4.

Summary for prediction 5

As in Experiment 1, if words have a higher concentration of consonants, as is found with short words commencing with a nasal-other consonant cluster, this increased the difficulty of spelling nasals in consonant clusters. This finding was more consistent than in Experiment 1, with the hardest word to spell having a ratio of three consonants to one vowel.

Prediction 6—adding nasals

Children again had a tendency to add nasals in contexts where a nasal might be expected. Apart from one word spelled by one child, nasals were only added to words that already had a cluster; ($F_1(2, 84) = 15.48$, $P < .001$, $\eta^2 = .26$, F_2 n.s.). Children who added nasals were however less likely to add a correct nasal than an incorrect one given the phonetic context within the word ($t_1(17) = 10.40$, $P < .001$, $d = 5.04$, t_2 n.s.); the most common type of nasal consonant added was the one that was not already represented in the word (e.g., *mvi* spelled as MNVI).

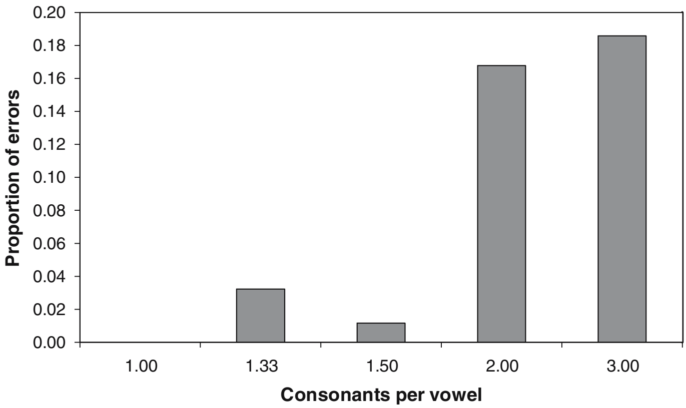


Fig. 4 Experiment 2: nasal errors by phonetic density of words

Children were significantly more likely to add a consonant to form the first consonant of an initial consonant cluster rather than to form the second consonant of a cluster ($t_1(42) = 4.09$, $P < .001$, $d = 0.79$, t_2 n.s.).

Summary for prediction 6

As in Experiment 1, children were likely to add nasals to words in contexts that might contain, or that already contained, nasals.

Prediction 7—effect of spelling skill

Children in grade 3 and 4 did not make significantly different numbers of errors, either overall or on nasal or other consonants in consonant clusters. Neither did age affect spelling significantly overall or specifically on consonants of either type in clusters.

Again children were divided into groups according to whether they were good or poor spellers, whether they had scored above or below the median score.

Children whose scores were below the median were no more likely to make errors on the nasals in consonant clusters but were more likely to make errors on the other consonant in the cluster ($t(20.67) = 2.62$, $P = .016$, $d = 0.84$).

Summary for prediction 7

In contrast to Experiment 1, there were no significant differences between the groups in the number of errors made on the different types of nasal clusters.

General discussion

To summarise our findings, in both experiments it was found that consonant clusters consisting of a nasal consonant first and another consonant second were harder to spell than words with either type of consonant alone. Overall this increased difficulty was due to spelling errors in the nasal consonant rather than the other consonant.

Our study has been carried out in a non-European language, which has a number of features that are not found in previously studied European languages. Nevertheless children learning to spell seem to make errors for the same reasons as, and in some cases errors that are phonologically equivalent to, those found in children learning to spell both regularly spelled and inconsistently spelled European languages, including English and Dutch (Treiman et al., 1995). Children's spellings seem to rely heavily on their phonological representations of words, and not on visual memory, nor do their spellings represent accurately conventional orthography. There are however important differences between the errors made in this study and those in previous studies, that reveal interesting new information about the possible phonological structure of words.

Why nasals are so difficult to spell

The varying difficulty of spelling nasals in different contexts can give a clue as to the reason for the difficulty of spelling nasals. There may be a number of reasons why some types of nasal consonants are easier to spell than others, as follows.

Salience

We initially hypothesised that salience would be the primary reason why nasals were more difficult to spell than the other consonant in clusters, and why some nasals might be more difficult to spell than others. Nasals themselves may be of lower salience than other consonants, and they may be made more or less salient by a variety of other factors.

Nasal consonants tended to be misspelled, in Experiment 1, more often if they were non-syllabic than if they were syllabic, even in the same position in the word. Syllabic nasals exist in some pronunciations of English words (such as ‘‘button’’ or ‘‘album’’), and Treiman, Berch, Tincoff, and Weatherson (1993) and Read (1975, 1986) have both investigated children's spellings of these. However, in Treiman et al.'s data errors on the nasal consonant are not reported, only children's spellings of the vowel with which such syllabic nasals are usually spelled, and none of the syllabic nasals used were in clusters; all were word-final. In Read's data some clusters similar to the Kiswahili clusters (e.g., ‘‘didn't’’) are investigated but again errors on spelling the nasal itself are not reported. In both studies it is not possible to determine if children always spell the nasal consonant correctly or if only spellings that include the nasal consonant were reported because the spelling of the vowel letter was of greater interest.

Although whether a nasal in a cluster is syllabic or not does affect the difficulty of spelling (these two types of clusters were compared directly in Experiment 1) for other aspects of saliency the data do not entirely confirm our hypothesis. Among non-syllabic consonants in Experiment 1, and among syllabic nasals in Experiment 2, more errors were made when the consonant was stressed than when it was unstressed, and in words with stressed clusters, more errors were made where the cluster was initial than where it was medial. Saliency of the cluster therefore cannot be the only explanation for variation in difficulty. Studies to date in English (Stemberger & Treiman, 1986; Treiman et al., 1995) have only used monosyllabic words in their investigation of errors in consonant clusters, and hence have not been able to investigate the role of stress and word length in such errors.

Expectations

We also hypothesised that children would use their knowledge about where nasals might be written to add nasals in appropriate positions. Our findings suggest that children seem to have such expectations about where nasals should be in words. They change nasals at least as frequently as they drop nasals, and they make errors involving adding nasals to previously existing clusters and before voiced consonants. Expectations about what type of nasal might be in a word may also mislead children into making errors on nasal consonants.

Phonetic density

Phonetic density, defined here as the ratio of consonants to vowels, explains errors very well. We did not originally hypothesise this factor as an influence on children's spelling of consonant clusters, but given our findings in both experiments of more difficulty with shorter words it seems that some feature of shorter words must be making them harder to spell. Phonetic density is one such possible feature.

When children know there is a nasal cluster in a word they seem to find it harder to pinpoint both the location of the nasal and which nasal they should be using if the word is more phonetically dense—i.e. has more consonants per vowel. In both experiments this variable was able to explain children's difficulties with nasals in clusters better than stress, word length, or position in the word.

Although English-speaking children often appear to find consonants easier to represent in their early spellings (Read, 1986; Treiman, 1993), children learning to spell Romance languages such as Spanish and Portuguese (which have both phonological and orthographic systems that more closely resemble Kiswahili) seem to find the opposite: vowels are easier to represent while consonants are harder (Ferreiro & Teberosky, 1982; Nunes Carraher & Rego, 1984). It is likely that this extra difficulty with consonants leads words with a higher proportion of consonants (those we have termed phonetically dense) to be harder to spell.

Overall it seems that a combination of

(a) Our original hypothesis of low *saliency* (syllabic nasals are easier to spell correctly than non-syllabic nasals; nasals in general have low phonetic substance and this could explain why they are the misspelled consonant in a consonant pair; in other types of initial clusters in other languages, the second, less salient, consonant is harder to spell) and
(b) The variable identified post-hoc, *phonetic density* (clusters in short words are harder to spell, and clusters are harder in general to spell than single consonants)

may provide the best explanation for many types of phonological spelling difficulty in beginning spellers.

Comparisons with other languages

This misspelling of nasals in consonant clusters that we have investigated was found in both word-medial clusters (as in English) and word-initial clusters (which are not found in English, or any other previously studied language). In English words that start with a consonant cluster, children are more likely to omit the second of the two consonants (Treiman, 1991). However, when nasal-other consonant clusters occurred at the beginning of a word, children learning to spell Kiswahili still made errors on the nasal rather than the second of the two consonants; the opposite pattern to that found in other languages. In our data the second consonant of the word was never omitted more frequently than the nasal, and in all word groups bar one it was omitted less frequently.

It has been suggested using data from English (Stemberger & Treiman, 1986) that initial consonants in clusters should always have fewer errors than the second or later consonants in clusters, and further that addition of an initial consonant before another consonant should be rare. In fact, as well as omission of the initial consonant, addition of an initial consonant was also a relatively common error (8% of errors in each experiment were the addition of nasals, and of these 36% in Experiment 1 and 76% in Experiment 2 were in initial position). It is possible that if Kiswahili had been the first language on which such research had been carried out, a different structure for consonant clusters might have been proposed.

Stemberger and Treiman (1986) also suggest that younger children, who have not yet mastered consonant cluster production, may omit the first consonant of a cluster in speech production, but that older children and adults who have mastered cluster production will make more errors omitting the second consonant of the cluster, or adding a second consonant. The children in our study were aged 10–15 years of age, so that even the youngest children can be reasonably expected to have mastered pronunciation of consonant clusters. It must therefore be the phonological representation of these clusters that differs from an adult representation, probably due to the children's incomplete literacy development.

Conclusions

Previous studies of spelling and speech errors in consonant clusters (e.g., Stemberger & Treiman, 1986) use data from English to imply that there is a universal underlying structure to initial consonant clusters, with the first consonant always more salient than the second consonant. Here we show that this assumption of universality is a dangerous one.

Taken together our data strongly suggest that children find phonetically dense words, and parts of words (such as clusters), difficult to represent as separate phonemes. This is true even for a regularly spelled, generally phonetically "light" language such as Kiswahili. Children learning to spell English are generally assumed to have particular problems due to the irregular nature of its spelling system. It is possible that the phonetically dense nature of English phonology may add to children's problems. Children learning to spell English do not seem to have the same general difficulty with consonants (over and above vowels) that children learning to spell Spanish, Portuguese, and

Kiswahili seem to have (Ferreiro & Teberosky, 1982; Nunes Carraher & Rego, 1984; Read, 1986; Treiman, 1993). It is therefore also possible that English-speaking children might display the opposite pattern to Kiswahili-speaking children—greater difficulty spelling words with lower phonetic density. However, English-speaking children have more difficulty with words containing consonant clusters (those that are in fact more phonetically dense) than with words containing single consonants (which are less phonetically dense) (Treiman, 1991; Treiman et al., 1995) so the direction of difference may be the same as in Kiswahili.

Further research in English, systematically varying the phonetic density of words, can elucidate these possibilities. However our study highlights the fact that most research on literacy is carried out in closely related, European languages, where many factors that might be relevant to children's literacy performance cannot be varied; the study of previously under-investigated languages is crucial to our understanding of literacy development.

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