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The sbelling of sdops: Preliterate children's spelling of stops after /s/

RACHEL HANNAM[1], HELEN FRASER[2,3] and BRIAN BYRNE[1,3]
[1]*School of Psychology, University of New England, Armidale, NSW, 2351, Australia;* [2]*School of Languages, Cultures and Linguistics, University of New England, Armidale, Australia;* [3]*Language and Cognition Research Centre, University of New England, Armidale, Australia*

Abstract. Newly literate children have a tendency to spell s-stop sequences in words like *spin*, *stop*, *sky* with B, D, G (SBIN, SDOP, SGY), rather than with standard P, T, K. This observation potentially has implications for theories of English phonology as well as of language and literacy acquisition. Understanding these implications, however, requires data about the spelling preferences of preliterate children. In this study, a training-and-transfer design was used to test these spelling preferences in preliterate children. Results confirm that these children relate words with stops after /s/ to words with initial /b, d, g/ rather than to words with initial /p, t, k/. The paper outlines several possible interpretations: that preliterate children have a different phonemic analysis from adults, that they believe spelling represents archiphonemes that they believe spelling represents allophones, and that their early spelling attempts track the phonetic surface. The data suggest rejection of the second interpretation and in our view favour the last over the remaining interpretations. Several theoretical issues are raised that need to be resolved before a full account of the data can be offered.

Key words: Early literacy, Phonetics, Phonological awareness, Phonology, Spelling

Introduction

Treiman (1985) found, as one result in a larger study, that a substantial minority of kindergarten children systematically use B, D, G to spell stops after /s/ in words such as *spin*, *stop*, *sky*, where standard spelling requires P, T, K. This potentially has implications not just for the study of literacy acquisition but for theories of English phonology. If children naturally spell stops after /s/ with B, D, G, it might suggest that the standard spelling is an arbitrary convention rather than a reflection of the underlying phonology of the language. As (Fink, 1974) puts it, ''Having learned to write P after S, the language user begins to hear /p/ after /s/ where he had previously heard /b/'' (p. 158).

This is plausible in light of other 'spelling effects' in perception. It is well known that people are greatly influenced by spelling in their analysis

of speech (Derwing & Dow, 1987). For example, many speakers of non-rhotic dialects such as Australian English believe they pronounce an /r/ at the end of words like *car* because an R occurs in the spelling even though these dialects lost postvocalic /r/ hundreds of years ago.

As Treiman herself points out, however, the implications of her results for the issue of whether standard spelling is at odds with the underlying phonology are not certain. Although the number of her newly literate subjects who preferred the non-standard spelling was substantial, it was still a minority. This may well have been, as she suggests, because by the time children have acquired sufficient literacy to participate in her study, some have already attained sight familiarity with the standard spelling of these sequences. Indeed her results contain the tantalizing suggestion that it was the least literate children in her sample who were most likely to prefer the non-standard spelling. To confirm this suggestion and pursue the theoretical implications, data from subjects known to be unbiased by knowledge of standard spelling are required.

The difficulty in obtaining such data is, as Treiman notes, the paradox of how to test the spelling behavior of preliterate children. The current paper reports results of a training and transfer study that allowed us to investigate the spelling preferences of children in the earliest stages of literacy acquisition. To present the study, a little background is needed.

Background

As with many children's errors, there is some logic to the non-standard spelling behavior under consideration. Adults naturally assume the sound after /s/ in stop is the same phoneme, /t/, as the first sound in *top*, seldom noticing that the pronunciation of *stop* is indistinguishable from that of *sdop*, or realizing that, since there is no contrasting word *sdop*, it would be quite possible to equate the second sound with initial /d/. In fact, the children's 'error' is a more phonetically accurate representation of the pronunciation than the adult spelling.

English has two sets of stop phonemes, /p, t, k/, usually called 'voiceless', and /b, d, g/, usually called 'voiced' (though see Docherty, 1992, for discussion of these terms). The voiceless phonemes have two very well known allophones (variant pronunciations): when they occur initially in a stressed syllable, they are aspirated (pronounced with a small puff of air); when they occur after syllable initial /s/, they are unaspirated (no puff of air). This makes the /t/ in *stop* different from the /t/ in *top*.

The interesting thing is that the lack of aspiration makes /p, t, k/ after /s/ very similar to initial /b, d, g/. There are some subtle differences,

however. For example, as Treiman (1985) points out, the pitch of the following vowel is somewhat higher after the de-aspirated stops. These subtle differences, however, are of little relevance to perception. If the /s/ is removed from words like *stop*, the result is perceived as beginning with /b, d, g/ (i.e., *stop* without the /s/ is heard as *dop*). Reeds and Wang (1961) excised /s/ from recordings of words such as *spat* and *scold*, and played the resulting sounds to adult speakers of English. Twelve listeners heard 30 items each, and 98% of the words were identified as beginning with /b, d, g/ rather than /p, t, k/, that is, as *bat* and *gold*, rather than as *pat* and *cold*. Looking at the situation the other way, Sawusch and Jusczyk (1981) found that when fricative noise corresponding to /s/ is added to the beginning of voiced stop syllables (e.g., /ba/), subjects identify the stop as voiceless (i.e., /spa/).

What we have then is a phonological ambiguity – a case where the same phonetic material can potentially be assigned to two different phonemes. Indeed, if phonetic similarity were the main criterion for phoneme assignment, it would make more sense for stops after /s/ to be assigned to /b, d, g/ than to standard /p, t, k/ (Crowley, Lynch, Siegel, & Piau, 1995). However, phoneme assignment depends not on phonetic criteria alone but on the patterning of the sounds in the language as a whole, and few phonologists seriously maintain that stops after /s/ belong to the voiced phonemes. We return to this line of discussion after presenting the results of the experiments.

In Experiment 1, preliterate children were first screened to ensure they were not already familiar with the correct spelling of words with s-stop sequences, then trained on a simple phoneme deletion/addition task to ensure that they could recognize /s/ and add it to a word to create a new word (e.g., *s* + *o* makes *so*, *s* + *it* makes *sit*). Finally they were tested to see whether they preferred to add /s/ to a word with /p, t, k/ or with /b, d, g/ to create a given s-stop word (for example, if asked to create *spit*, did they prefer to add /s/ to *pit* or *bit*?).

Experiment 1

Method

Participants

Twenty-four children, 11 boys and 13 girls, with a mean age of 5 years 10 months (range 4 years 11 months to 6 years 7 months) were selected from three Grade 1 classrooms in a state primary school in Queensland, Australia. Teachers were asked to nominate children who could be

expected to keep on task because of the nature of the learning component in Stages 2 and 3. The children's literacy level was not formally assessed though the screening procedure (described below) tested for the abilities most relevant to the current task. Grade 1 is the first year of formal schooling in Queensland. School authorities report that the school is in a low SES area, with substantial numbers of children with learning disabilities. The orientation in teaching is skills-based rather than whole language. It seems unlikely they could have performed the task in Treiman (1985) of choosing which of a set of ten letters best spelt the second sound in a series of spoken syllables such as /ska/, /spa/, /sta/, /stra/. The words used in the critical final phase had not been explicitly taught by the Grade 1 teacher.

Materials

Ten s-stop words were chosen such that they yielded real words judged to be familiar to children of this age, with either /p, t, k/ or /b, d, g/ (in Australian English) when the s was deleted. The words were *spit*, *spin*, *spill*, *spy*, *spark*, *sport*, *stick*, *start*, *stuck* and *skate*. The screening stage used the letters P, T, K, B, D, G, and S, and alternative spellings for each of the ten s-stop words (e.g., SBOT and SPOT). The training stage used the letters S, O, E, and the words IT and AT. For the transfer stage, cards displayed the words with /p, t, k/ and /b, d, g/ (e.g., PIN and BIN, GATE and KATE, TUCK and DUCK).

For the spelling test, flash cards were created displaying each of the letters and words of the experiment in similar upper-case letters. Pronunciation of the words was given by the experimenter as this was felt to be more natural than using recordings. When the children were asked to judge where to put the card with S, they were instructed to say the word themselves and listen to their own pronunciation.

Procedure

The experiment had three stages: screening, training (with two sessions) and transfer. Most children were able to complete all stages on a single day, but for a few, school requirements meant that testing had to be spread over several days. The maximum spread was 5 days.

In the screening stage, the children were first shown cards with P, T, K, B, D, G, S to be sure they could give the sound for each letter. They were then shown 20 cards, one at a time, each displaying alternative spellings for each of the ten s-stop words (e.g., SBOT and SPOT). The order of voiced and voiceless spellings was alternated, allowing for each word to be tested two times. The experimenter provided the spoken form of the word. Children were then asked to point to the written word they thought

might represent the spoken form. No feedback was given for any item. A score of 13 correct out of 20 attempts was chosen as the cutoff (binomial $P = .06$). That is, we included in the next stage only children who scored 12 or less and 21 of the 24 did so. The three with a higher score were excluded on the grounds that they may already have known the correct spelling of the words.

In the first training session, children were drilled on letter names for O and E, and on the sound for letter S. Some children knew the sounds for O and E as in *hot* and *bet*, so were instructed to focus on the letter names. Children were then told they were going to play a reading game. They were taught the spelling for the word *stop* by placing the S card before the O. They were told to read this word and then asked to take away the S. They were asked if they knew what the leftover 'word' was. Most children replied /o/. If an error was made, the child was told the answer. The next instruction was to replace the S card and read the resulting word. Children almost always labeled it *so* on the first trial, and were asked to remove and replace the S two or three times. The same process was repeated for SE (a simplified spelling of *see*). Each child received approximately 10 min training in adding and deleting /s/ from these vowels in the first session.

In the second training session, children were reminded of the SO/SE training and this time were asked if they could place S in front of O or E to form the word so. All children except one were able to perform this task independently. Training continued by drilling children on IT and AT until they could read them correctly. They were then given the pronunciation of the word *sit* and asked to listen carefully to themselves as they repeated it back. They were asked to place the S card before either AT or IT to form *sit*. Only one child was unable to do this. The 20 children who successfully completed this transfer task continued on to the next stage of the experiment.

For the critical transfer task, the children were first trained to discriminate pairs of written words such as PIT and BIT and drilled by means of flash-cards until they could read them confidently. Next, they were shown a picture card for *spit* and asked to repeat the word two or three times. They were then given the S card and told that they could form this word, *spit*, by placing the S before one of the word cards. The experimenter told the children to listen carefully to themselves as they said *spit* and then asked if they thought the word contained *bit* or *pit*. Children then placed the S card before the word they thought was used to spell *spit*. No feedback was given. This process was repeated for the other nine items *spin*, *spill*, *spy*, *spark*, *sport*, *stick*, *start*, *stuck* and *skate*, using

the appropriate written word cards (e.g., PIN and BIN, GATE and KATE, TUCK and DUCK).

At the end of the experiment, children were advised that B, D and G never occur after /s/ in English and that they should always use P, T or C/K.

Results and discussion

The numbers of children choosing between 0 and 10 conventional spellings are shown in Table 1. Overall, the B, D, G spelling was far more common. Even with two deviant high scores (8 and 10) in the data, the mean score for conventional spellings was 2.55 (SD = 2.66) and the mode was 1. A single sample *t*-test against the chance score of 5 was significant, t ((19) = 4.11, $P < .001$, two-tailed).

As noted, one child achieved a score of 10/10 and another, 8/10. This is surprising given that these children failed the screening test. Perhaps they did not properly understand the screening test instructions or simply did not concentrate during the test. Another possibility is that between the first and second sessions (4 and 5 days in these cases) the children discovered, either from school or some other environment, or indeed from the experiment itself, that P, T, K occur after /s/, and not B, D, G. For most children, literacy learning is at its most rapid in the first

Table 1. Frequency distribution of children's scores, Experiment 1.

Number of conventional spellings selected	Frequency
0	4
1	5
2	3
3	3
4	2
5	1
6	0
7	0
8	1
9	0
10	1

Table 2. Number of voiced spellings for each of the ten test items, Experiment 1.

Test item	No. of voiced spellings (max = 20)
spy	17
spark	13
spit	17
spin	16
stick	17
skate	8
sport	19
spill	16
stuck	18
start	9

grade (Woolfolk, 1998). Alternatively, these scores could reflect different phonological abilities of these individual children.

Table 2 shows, for each test item, the number of children who chose the B, D, G spelling over the P, T, K spelling. Values over 13 have a binomial probability of less than .05, with a value for 13 (*spark*) of .06. Thus significantly more children chose B, D, G for eight of the ten words (counting *spark*). The two remaining words were *start* and *skate*. A potentially confounding factor might explain the low and non-significant score for the item *start*. Two children remarked during testing that they recognized START from their computer at home. The low score for *skate* may be related to indications that velars are the least likely to be classified as voiced after /s/ (Fink, 1974). Unfortunately, the material in Experiment 1 does not allow full investigation of this factor since only one /sk/ word was used, but it will be noted that the difference between velars and the other two places of articulation was not significant in Experiment 2.

Table 3 compares the distribution of Treiman's (1985) youngest children's responses with the distribution of responses in the current study. The value V/(V + VL) is the proportion of B, D, G responses (V) relative to all responses (V + VL). Its value would be .00 for a child who consistently spelled stops after /s/ in the conventional manner and 1.00 for a child who consistently gave B, D, G responses. As shown, only 29.5% of Treiman's participants favored B, D, G spellings (i.e., had V/(V + VL) values of more than .50), whereas 85% of participants in the current study favored B, D, G. Treiman's youngest experimental group had a mean V/(V + VL) value of .32 compared to participants' mean in the present

Table 3. Comparison of distribution of V/(V + VL) values for Treiman's (1985) youngest participants with participants from the present study.

Group	Percentage of participants with V/(V + VL) in range:			
	.00–25	.26–.50	.51–.75	.76–1.00
Treiman's participants ($N = 24$)	58	12.5	12.5	17
Current participants ($N = 20$)	10	5	25	60

study of .75. The difference between the two groups is significant at the .001 level $t\,(19) = 7.13$, $P < .001$. Thus, the results confirm that children who are essentially preliterate choose to relate words with stops after /s/ to words with initial /b, d, g/ than to words with initial /p, t, k/.

Experiment 2 aimed to rule out the possibility that the difference between adult and child perception of these sequences stems from differences in production. Though children aged 2 and 3 often have trouble pronouncing s-stop clusters, normal children can do this before entering preschool (Catts & Kamhi, 1984). But do they do so in a way similar to adults? A design similar to Reeds and Wang's (1961) tape-splicing study was used to answer this question.

Experiment 2

Method

Participants

Five boys and five girls with a mean age of 5 years 11 months (range 5 years 6 months to 6 years 3 months) were randomly selected from the same school as in Experiment 1. It was not possible to use the same children as in Experiment 1. However, all but three were from the same grade in the same school. The other children were from the preschool attached to the school. There were no obvious differences in dialect or literacy level. Five phonetically untrained adults from the same school, blind to the purpose of the study, judged the edited recordings.

Materials

Twenty s-stop words were chosen such that they yielded two possible words when the /s/ was deleted (for example, *spit* yields *pit* and *bit*). For six items, deleting the /s/ portion yielded one real word (in Australian

English, a non-rhotic dialect) and one possible but not real word (e.g., *tar* and *dar* from *star*). The remaining 14 words yielded two real words of Australian English. In total, there were eight *p*/*b* items, seven *t*/*d* items and five *k*/*g* items. The words were *spit*, *spin*, *start*, *stick*, *spy*, *star*, *skate*, *spill*, *stuck*, *space*, *speak*, *stare*, *sport*, *screw*, *spark*, *stamp*, *sky*, *stay*, *skin* and *still*.

Procedure

A picture card was developed for each word and the children were asked to name the picture. Coaching was provided where necessary to ensure they produced the appropriate word for each card. Pilot studies had previously suggested that children became bored with 20 items, so each child was recorded saying only half the set (ten words from each of ten children, giving 100 words in total).

A professional mini cassette recorder (Panasonic RQ-L349) with a condenser microphone (SONY ECM-F8 Electret) was used to record the words onto a standard cassette tape. These recordings were then transferred via cassette deck (Realistic SCT-24 Stereo) onto an Apple Macintosh computer (LC475). Audio manipulation software (Macromedia SoundEdit Pro Audio) was used to convert the children's words into waveforms and excise the /s/ sounds from each one. The edited words were then re-recorded onto cassette via the cassette deck. Auditory inspection ensured that no significant degradation had occurred.

The final cassette tape was played to the adult listeners using a SONY dual-tape deck. Each adult listener heard two of the ten children reading ten words each, giving a full set of 20 words for each of the five adults (100 words in total). The adults were provided with response sheets and asked to circle the spelling option they thought best suited each word (e.g., *bit* or *pit*). They were advised that some of the items on the sheet were not real words. If they were unsure of an item they were told that they should omit it and try again when the set of words was replayed.

Results and discussion

All five listeners omitted between two and five of the 20 words on the first hearing, but only one remained undecided on any items (two, both for a *k*/*g* pair) after a second hearing. The listeners favored the B, D, G spelling option over P, T, K for 91 of the total of 100 items (five listeners by 20 words), choosing B over P 95% of the time, D over T 94% of the time, and G over K 80% of the time (counting the two undecided responses as evidence against a /g/ selection). The least convincing

subject selected 16/20 B, D, G spellings, $P < .01$. The K/G data, with 20/25 G selections across items and participants, appeared less robust that the other alternations, with 38/40 B choices and 33/35 D choices, but a comparison of the relative number of G (''worst'') versus B (''best'') selections showed no significant difference $\chi^2(1) = 2.21$, $P > .05$.

This study indicates that children, like adults, pronounce stops after /s/ in a manner phonetically more similar to initial /b, d, g/ than to initial /p, t, k/. The score for velars was lower than for the other places of articulation, fitting Fink's (1974) result that velar stops are least likely to be classified as voiced when played without the preceding /s/, but on the current sample size this was not a significant difference.

General discussion

Experiment 1 confirms what has been suggested in previous studies, that preliterate children, known to be unfamiliar with the standard spelling, see greater similarity between words with stops after /s/ and words with initial /b, d, g/ than words with initial /p, t, k/. This is in sharp contrast to the behavior not just of adults but even of children with only slightly higher literacy skills. Experiment 2 rules out the explanation that this reflects different patterns of pronunciation in these young children. Several interpretations present themselves as plausible and parsimonious.

Interpretation 1: The children have a different phonemic analysis from adults

The results could indicate that children assign stops after /s/ to phonemes /b, d, g/ rather than /p, t, k/. This clearly conflicts with the standard account of adult phonology.

One solution would be to suggest that the standard account is based on a spelling effect, and may be in need of revision. We saw above, however, that although stops after /s/ have been extensively discussed over many decades, few phonologists have seriously proposed that stops after /s/ should be assigned to /b, d, g/. This is because phoneme assignment depends not just on the phonetic description of sounds, but on the way the sounds pattern in the language. As Treiman (1985) notes, throughout the English phonological system, clusters of stops and fricatives tend to share voicing. For example, in syllable-final position, only voiceless stops occur after /s/ (e.g., *host*); plural and past tense morphemes are adjusted to conform to the voicing of the preceding consonant. Indeed, this is

common in all languages (Hockett, 1955). Even in a language like Italian, which represents clusters orthographically with SB, etc., the /s/ is pronounced as [z] so as to share voicing with the stop (Giannelli & Cravens, 1997). This in itself strongly supports assignment of stops after /s/ to the voiceless phonemes. Further support is given by the fact that a process of deaspiration of stops after /s/ is phonetically plausible and widely attested in languages of the world whereas the opposite is not (Ladefoged & Maddieson, 1996).

Phoneme assignment of stops after /s/, then, is understood with a fair degree of confidence for adult English. Of course, that does not mean it cannot be challenged on the basis of new data. However, more data from a wider range of studies, including studies of adult phonology, would be needed in order to overthrow such a well-established account. Children make many errors in the course of learning to spell (e.g., JRAGON for *dragon*, MUPS for *mumps*, etc.), many of which can be accounted for by reference to phonetics (Treiman, 1993). However, it is not generally suggested that these errors support a scholarly account of the mature phonological system that focuses on phonetic description rather than phonological patterning. Accepting Interpretation 1, in addition, requires an account of how and why children start with one phonemic analysis, and then change so quickly to another.

Interpretation 2: The children believe spelling represents archiphonemes

An archiphoneme is a representation of a sound in which a contrast that operates elsewhere in the phonology is neutralized (Trubetzkoy, 1939/1969). Treiman (1985) discusses the possibility that the children in her experiment used spelling to represent an archiphoneme. Though this interpretation was left open by Treiman's data, it is not supported by ours. If the children were focusing on an archiphoneme, we would expect them to be unable to decide whether stops after /s/ were voiced or voiceless, and to add S randomly to words with voiced or voiceless stop phonemes. However, they strongly favor words with the B, D, G spelling. This is in line with other arguments against the psychological reality of archiphoneme in phonology adult (Mompeán, 2004).

Interpretation 3: The children believe spelling represents allophones rather than phonemes

The data could be interpreted as showing that preliterate children expect spelling to represent, not phonemes, as in adult orthography, but

allophones. This interpretation too conflicts with well established observations. There are many types of writing systems, but it is virtually unknown for any of them to represent allophones (Byrne, 1998; Mackay, 1987; Olson, 1994). Of course it is possible that children start with a different view of writing to the one they eventually attain as adults. Indeed there is good evidence that this is the case. However that evidence suggests children initially hypothesize that writing represents not units of sound such as allophones, or even phonemes, but units of meaning, morphemes (Byrne, 1996). Accepting Interpretation 2, too, requires an account of how and why children move rapidly between a focus on morphemes, allophones and phonemes.

Interpretation 4: Children's very early spelling attempts are "literal" until they learn a more abstract concept of phonemes

On this account, early on children focus on the details of the sound stream and on similarities among speech sounds. Because stops after /s/ are deaspirated, they bear similarity to voiced stops, also lacking aspiration. The data here thus join with many observations by Read (1986) and Treiman (1993), for example, of such spellings as CHUSDAY (*Tuesday*), CHRIE (*try*), and PREDE (*pretty*), where phonetic properties dominate spelling. Note that this is *not* the same as accepting Interpretation 3, that children consider spelling to be based on allophones. Allophones are highly abstract linguistic entities (Laver, 1994), dependent for their definition on the prior acknowledgement of the phoneme as a linguistic unit, something that children at this age are accepted as not having done (Byrne, 1998). It is with the onset of literacy instruction that children's conceptions of phonology begin to approach that of literate adults (and of many linguists for that matter), aided by the orthography they are learning about and other aspects of the instructional setting (see Byrne, 1992, for a discussion of separate contributions of letter knowledge and reading instruction to this developmental progression). On this view, these data fit a reasonably well accepted view of literacy development, as follows: words and their meanings are first unified representations; a separation of sound and meaning as a general idea follows, as shown by sensitivity to rhyme and perhaps phonetically salient units such as /s/; links with orthography are initially built around morphemic units and their spelling forms, shifting to a focus on the speech stream, as detailed above; finally a more mature conception of phonological organization emerges, supported by alphabetic orthography, which itself is a reasonably faithful representation of the structures and their

relationships as captured in standard phonological theory. This analysis of course goes well beyond the data we have presented here, but we considered it useful to integrate our findings into a broader picture of literacy growth.

Thus, in this paper we have provided evidence that preliterate children relate words with stops after /s/ to words adults analyze as having initial /b, d, g/ rather than to words adults analyze as having initial /p, t, k/. We have suggested several possible interpretations, and further suggested that, by themselves, our data eliminate only one, Interpretation 2. More evidence and the resolution of various theoretical issues may allow refinement of the remaining interpretations.

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Address for correspondence: Brian Byrne, School of Psychology, University of New England, Armidale, NSW, 2351, Australia,
Phone: +61-2-67721478; Fax: +61-2-67733820; E-mail: bbyrne@une.edu.au