ORTHOGRAPHIC INFLUENCES ON INITIAL PHONEME DELETION TASKS

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ABSTRACT: Here the orthographic effects on initial phoneme deletion tasks with an adult population are examined. Three experiments were conducted, where participants listened to instructions to take the first sound away from a real word to create a new word. For half of the items it was also possible to use sound or spelling to do the task (e.g. /raɪs/ - /r/ = /aɪs/, rice – "r" = ice), but for the other half an orthographic strategy resulted in the incorrect spelling for the resultant word (/kɒf/ - /k/ = /ɒf/ "off", cough – "c" = ough). Longer reaction times were found for interfering items in Experiment 1, and in Experiment 2, with a slightly different method of stimulus delivery. In Experiment 3, participants were specifically instructed not to use spelling in the task, but the same result was observed nonetheless. The results suggest that orthographic processing is automatically activated during phoneme deletion with real words.

Phoneme deletion tasks have been used for decades as a measure phonological awareness. These are auditory tasks in which participants remove a sound from a word and say aloud the resultant string of sounds. In a landmark study, Morais, Cary, Alegria and Bertelson (1979) found that illiterate Portuguese participants made significantly more errors on these tasks than their literate counterparts. Read, Zhang, Nie and Ding (1986) conducted a similar study with two groups of Chinese participants. Both were literate in Chinese characters, but one was also literate in *Hanyu Pinyin*, a Mandarin alphabetic script. Read et al. found a similar difference to Morais et al. – the alphabetic literates performed better than did the non-alphabetic literates. Therefore, it can be concluded that learning to read an alphabetic script results in superior performance on phoneme addition and deletion tasks.

Morais et al. (1979) claim that the superior performance of literates over illiterates is due to the knowledge that words consist of individual *sounds*, and that individuals attain this knowledge through learning to read. In other words, learning to read an alphabet teaches people about phonemes. However, it must also be added that alphabetic literates have also gained the ability to use their knowledge of *graphemes* to manipulate sounds in words, and this may provide a more direct explanation for their superior performance. That is, knowledge of *phonemes* may not be a necessary prerequisite for successful performance on phoneme deletion tasks.

Stuart (1990) conducted a study with 9 year-old children to test for evidence of orthographic strategies in a medial phoneme deletion task, where the children were asked to remove the penultimate phoneme in CVCC words and nonwords. Stuart selected items with identifiable "orthographic" or "phonological" responses, such as /raɪnd/ "rind", where the phonological response is /raɪd/ "ride" and the orthographic response is "rid". Evidence was found for orthographic strategy use in good readers, but poor readers very rarely used an orthographic strategy. An interaction was also found between stimulus lexicality and strategy choice – the children were more likely to select a phonological strategy if the stimulus was a nonword rather than a word. This finding led Stuart to suggest that the use of an orthographic strategy depends on access to a stored orthographic representation. The adult alphabetic literates in Morais et al. (1979) and Read et al. (1986) were all experienced readers, and presumably had access to stored orthographic representations. The question for the present study is whether alphabetically literate adults use their orthographic knowledge in phoneme deletion tasks.

Stuart (1990) used medial phoneme deletion, whereas Morais et al. (1979) and Read et al. (1986) used initial phoneme deletion. As it is desirable that the present study is comparable with these latter two studies, initial phoneme deletion will be used. One drawback of this task is, however, that it is impossible to construct stimuli where the response clearly indicates the response strategy. Stuart was able to achieve this because many vowels in English have multiple orthographic representations. With initial phoneme deletion it is not possible to construct stimuli which take advantage of vowel representations. To overcome this problem, stimuli will be selected which should interfere with performance on the tasks if orthographic knowledge is active. Stuart has suggested that the use of an orthographic strategy depends upon access to a stored orthographic representation, so real words, rather than nonwords, will be used in the present study. There will be two groups of items, "non-interfering items" which are amenable to either a phonological or an orthographic strategy (e.g. /raɪs/ - /r/ = /aɪs/, rice – "r" = ice), and "interfering items" which are only amenable to a phonological strategy (/kɒf/ - /k/ = /ɒf/ "off", cough – "c" = ough). Longer reaction times (RTs) are predicted for interfering items than non-interfering items. The advantage of using RT data, in addition to error data only, as in previous research (e.g., Morais et al., 1979; Read et al., 1986; Stuart, 1990), is that an influence of orthography can be observed even if the participant obtains correct answers for all items. For example, in Stuart's study, orthographic representations for sounds could have been used in conjunction with a rhyming strategy to obtain the correct "phonological" response. That is, children may have articulated the word that rhymes with "cast" minus the "s", to obtain "cart". If this were so, then longer RTs would have been expected, due to interference with "cat", even when the correct phonological response is given.

In summary, it is possible that the superior performance of adult alphabetic literates over illiterates is due not to phonemic awareness *per se*, but to the availability of an orthographic strategy. If this is the case, then evidence for orthographic processing should be obtained, even if the correct phonemic response is given. It is hypothesised that RTs for correct responses will be longer for interfering items than non-interfering items.

EXPERIMENT 1

Method

Participants and Design. The participants were 24 native Australian English speakers obtained from the Introduction to Psychology course at the University of Western Sydney, Australia. All participants reported having normal hearing. The experiment was a single factor repeated measures design with two levels, "interfering" orthography and "non-interfering" orthography.

Stimuli and Apparatus. Items for the deletion task consisted of words where the removal of the first phoneme in the word resulted in another word. For example, the deletion of the /f/ from /fækt/ "fact", results in /ækt/ "act". There were two types of stimuli in the experiment, "interfering" and "non-interfering". For the non-interfering items, the deletion could be successfully conducted using letters instead of sounds - removing the letter "f" from "fact" also results in the correct spoken response. The interfering items were not amenable to an orthographic strategy – removing the /w/ sound from /wɜːθ/ "worth" leaves /ɜːθ/ "earth". In total, there were 36 items, consisting of 18 inconsistent and 18 consistent items. Items were matched for initial consonant and a two-tailed *t*-test revealed that the log word frequency (taken from CELEX) was not significantly different between the two groups of items ($t(34)=.342$, $p=.73$).

The stimuli were presented to the participants in random order. For each item, subjects were instructed to take away a sound from the word, and in the instructions the sound to be deleted was followed by a schwa (/ə/). For example, the instruction for "school" was, "take the /sə/ sound from /skuːl/". These 36 instructions, along with 11 consistent practice items, were recorded onto DAT at a sampling rate of 44.1KHz, in a sound attenuated room, by a male speaker of Australian English. The stimuli were transferred digitally onto computer and saved as sound files for use in the experiment.

The experiment was run on a Macintosh Performa 5260 computer using B/C PowerLaboratory software. The onset of the verbal response was measured using a voice key, which sent a pulse to the serial port of the Macintosh. Reaction time was calculated from the onset of the stimulus word in the instruction sentence.

Procedure. The experiment was conducted in a sound attenuated room. Participants listened to the stimuli through headphones and made their verbal responses into a microphone. The experimenter gave verbal instructions and examples, but no specific instructions were given regarding the use of an orthographic or phonemic strategy. Eleven non-interfering practice examples with feedback were followed by the 36 randomized experimental items with no feedback.

Results

The results are presented in Figure 1. Paired *t*-tests were used to compare consistent and inconsistent scores for each participant collapsed across items. There was a significantly ($p<.05$) longer mean RT to (correct responses) for interfering than non-interfering items ($t(23)=5.52$, Cohen's d (effect size)=.65), and also a significantly higher mean error rate ($t(23)=3.50$, $d=.75$). In addition to the usual analyses in which subjects is treated as the random factor in order to generalise from the sample of subjects to the population, analyses were conducted in which stimulus items was treated as the random factor in order to generalise to the population of items. Since the consistent and inconsistent items were not matched in a pairwise fashion, an unpaired t-test was used to compare scores for the items collapsed across participants. Mean reaction times were significantly longer for interfering than non-interfering items ($t(34)=2.69$, $d=.90$), but there was no significant difference for mean error rate ($t(34)=1.65$).

The mixed results in the error data may be due to large variation. There were some interfering items for which no errors were made (e.g., beg/egg, fuss/us, slim/limb), and others which showed a large error rate (e.g., quite/white: 58%, sphere/fear: 50%, scarf/calf: 38%). There also appeared to be some problematic non-interfering items, such as "frail/rail", which had an error rate of 25%. There were also two items in the experiment which had three-consonant onsets, "strain/train" (non-interfering) and "street/treat" (interfering), both of which had error rates of 33%. Two items with /tʃ/ onsets (chart/art, cheese/ease) were also problematic, as some participants responded /haːt/ and /hiːz/.

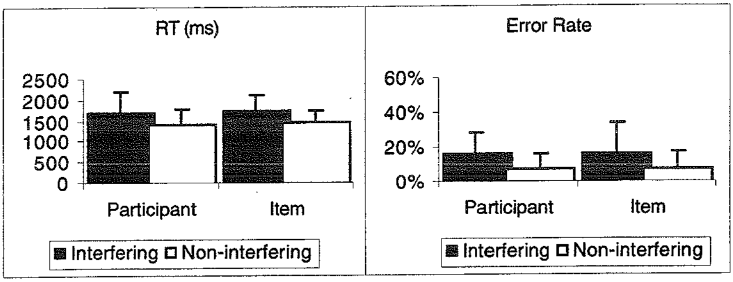

Figure 1. Reaction times and error rates for Experiment 1 collapsed across participants and items. Error bars represent standard deviations.

Discussion

Evidence for orthographic processing was found in Experiment 1. Participants took longer to produce the correct response when the spelling of the target word interfered with the correct phonemic response (e.g. worth – earth) than when the spelling did not interfere (e.g. fact – act). This suggests that orthographic processing accompanied performance on the phoneme deletion task, even when the correct phonemic response was produced. The error data were not conclusive, as a significant difference was found in the participant analysis, but not in the item analysis, possibly due to the large amount of variance in the item data. As noted in the results, participants made no errors on some items, but a large number of errors on others. This does not pose a problem for the present study because orthographic influences in the production of the *correct* response are of interest.

One possible confound in Experiment 1 is the manner of stimulus presentation. When learning to read, some children are taught letter labels which are similar to the prompt given in the experiment to indicate the to-be-deleted sound, e.g. /æ/ /bə/ /kə/ /də/ instead of /eɪ/ /biː/ /siː/ /diː/. Thus, the embedding of the to-be-deleted sound in a neutral carrier syllable may have increased the likelihood of orthographic strategy use, as some participants may have visualised the corresponding letter when presented with the sound. To overcome this problem, participants in Experiment 2 will be presented only with a the target word, and asked to take away the first sound.

EXPERIMENT 2

The results of Experiment 1 may have been influenced by the manner of stimulus presentation, so in Experiment 2, the participants will be presented with the target word only and asked to delete the first sound.

Method

Participants and Design. The participants were 22 monolingual Australian English speakers from the same university course. All participants reported having normal hearing and the design was the same as Experiment 1.

Stimulus Materials and Apparatus.

In Experiment 1, the stimuli were presented in a sentence, and the to-be-deleted sound was provided. For example, "take the /bə/ sound from /bla:st/". In Experiment 2, only the target word was presented (i.e., /bla:st/), because the presentation of the to-be-deleted sound may have influence orthographic strategy use. Following the examination of the error data in Experiment 1, the items "strain" and "street" were removed, because the errors made on these items seem to be unrelated to the manipulation of the independent variable. The items "chart" and "cheese" were also removed, and "frail" was replaced with "fact". A further two pairs of items were removed to balance the overall word frequency of the lists ($t(26)=.56$, $p=.59$), leaving 14 items in each list, and 28 items in total. The items were recorded in the same manner as Experiment 1 and the same apparatus was used.

Procedure. The procedure was the same as Experiment 1.

Results

The results are presented in Figure 2. For the participant analysis, there was a significantly ($p<.05$) longer mean RT to correct responses for interfering than non-interfering items ($t(21)=3.93$, $d=.51$), and a significantly higher mean error rate ($t(21)=5.54$, $d=1.41$). For the item analysis, there was a significantly longer mean RT for interfering items ($t(26)=1.89$, $d=.72$) and, unlike in Experiment 1, there also a significantly higher mean error rate ($t(26)=2.46$, $d=.93$).

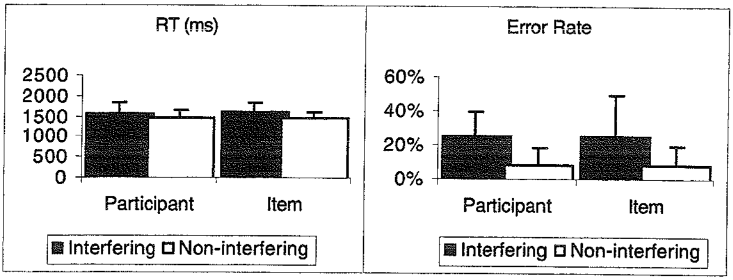

Figure 2. Reaction times and error rates for Experiment 2 collapsed across participants and items. Error bars represent standard deviations.

Discussion

The results of Experiment 2 confirm the influence of a word's orthographic representation on the production of a correct response in a phoneme deletion task. Unlike the results of Experiment 1, the error data also clearly support this hypothesis. Participants made significantly more errors on the interfering items than the non-interfering items. In fact, Figure 2 shows that the error rate for interfering items seems to be higher for Experiment 2 than Experiment 1, in spite of the removal of some problematic items. In other words, the provision of the to-be-deleted sound may have actually assisted performance in Experiment 1. The effect size for the RT analysis reduced slightly between Experiments 1 and 2, but this may have been a function of the increased error rate, which resulted in a smaller number of data points for the RT analysis. Therefore, the results of Experiment 2 show that the method of stimulus presentation was not responsible for the orthographic influence in Experiment 1, as a significant difference in RT was found between interfering and non-interfering items.

Having established that the effect observed in Experiment 1 is not due to the manner of stimulus presentation, one further question is whether the orthographic influence is automatic or under conscious control. Participants in Experiments 1 and 2 were not given any specific instructions about the use of an orthographic strategy, so it is possible that they were simply unaware of the distinction between sounds and spelling and that the results are due to a strategy choice, rather than an automatic influence of orthography. Thus, a replication is required where participants are instructed not to use spelling in the task. If an RT difference is still observed, then this will suggest that the influence of orthography on phoneme deletion tasks is automatic rather than a mere strategy choice.

EXPERIMENT 3

Participants and Design. The participants were 24 monolingual Australian English speakers from the same university course as in Experiments 1 and 2. All participants reported having normal hearing and the design was the same as in Experiment 1.

Stimulus Materials and Apparatus. To ensure comparability, the stimulus items in this experiment were exactly the same as those in Experiment 1, with the full 18 items. Thus, the materials and apparatus were the same as Experiment 1, except for 5 of the practice items, which were replaced with examples of interfering items.

Procedure. The procedure was the same as Experiment 1, except that the participants were told use the sounds only and not the spelling to do the task, as this might interfere with the correct response. They were also given a verbal example, /drɛd/ "dread", where the correct phonemic response is /rɛd/ "read", but the spelling can also be pronounced /ri:d/, which would be the incorrect answer. The practice session also contained examples of interfering items and feedback was given.

Results

The results are presented in Figure 3. For the participant analysis, the RT to correct responses was significantly ($p<.05$) longer for interfering than non-interfering items ($t(23)=3.12$, $d=.33$), and there was a higher error rate for interfering items ($t(23)=2.23$, $d=.45$). For the item analysis, there was a significantly longer RT for interfering items ($t(34)=1.73$, $d=.58$), but no significant difference in error rate ($t(34)=.95$).

Discussion

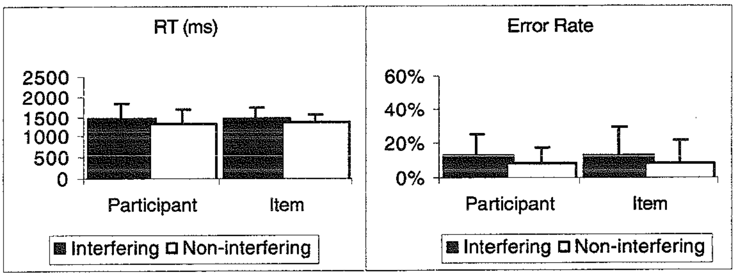

Figure 3. Reaction time and error rate results for Experiment 3 collapsed across participants and items. Error bars represent standard deviations.

The results of Experiment 3 replicated the results of Experiment 1. An influence of orthography was found in the deletion task, despite the fact that the participants were instructed not to use spelling to do the task, and were given practice with interfering items. Therefore, on average, the influence of spelling on the production of the correct phonological response seems to be automatic, rather than simply a strategy choice. The error rates follow a similar pattern to Experiment 1, but RTs seem to be faster and the effect size is smaller. Thus, it is possible that some of the variance in Experiment 1 may have been due to orthographic strategy choice. Nevertheless, there was still a significant difference in RT between interfering and non-interfering items in Experiment 3, and the effect size estimate still indicates an important difference.

GENERAL DISCUSSION

The results of these three experiments are consistent with the notion that orthographic processes are necessary for successful performance on deletion tasks, however it should be noted that they provide no direct evidence for this contention. They simply suggest that other orthographic processes are active during the task. The significantly higher error rate for interfering items in Experiment 2 may provide some support for the idea, but in Experiments 1 and 3, the error rate data are inconclusive. Thus, one question for future research is whether orthographic processes are intrinsic to performance on phoneme deletion tasks, or whether they simply interfere with phonemic processing.

As Stuart (1990) suggested, one possible explanation for the influence of orthography is lexical storage. This was also stated by Perin (1983), who suggested that for literate individuals, tasks requiring word level processing may automatically involve the activation of an orthographic code in addition to other codes. In the present series of experiments, the spelling for the interfering stimulus word may have been automatically activated, and may have inhibited the production of the correct response. If this were the case, then there would be no influence of orthography in nonword deletion, because nonword items would not have an internal orthographic representation. We have conducted similar experiments with nonwords (Tyler & Burnham, in press), such as /smɒnθ/ "smonth" and /swænt/ "swant", where an orthographic strategy results in the spelling for a real word (e.g., "month"), rather than the correct nonword (e.g., /mɒnθ/). The results showed no interference from spelling, which supports the idea that lexical storage is responsible for the orthographic interference observed in the present series of experiments.

In order to investigate further whether lexical storage is responsible for the influence of orthography on these tasks, participants could be asked to perform a lexical decision on their deletion response. If the orthographic interference is due to lexical access, then a) for real words, lexical decision should be slower and there should be more errors for interfering than non-interfering items, and; b) for nonwords, lexical decision should be slower, and there should be more false positives, for interfering (e.g., /smɒnθ/ "smonth") than non-interfering items (e.g., /smænt/ "smant").

In summary, the results demonstrate that for literate, adult English speakers there is evidence for orthographic processing in phoneme deletion tasks, at least when the stimuli are real words. In contrast to Stuart's (1990) study, where a child's response could be identified as either an orthographic or phonological strategy, Experiment 1 showed evidence for an orthographic influence even when the correct phonological response was given. However, given the current experimental design it was not possible to ascertain whether phonemic or orthographic knowledge was responsible for the production of the correct answer. Therefore, with respect to the contention of Morais et al. (1979) that phonemic knowledge is responsible for the superior performance of literates in phoneme deletion tasks, the results of the present series of experiments demonstrate that further investigation is required into alternative influences, such as the knowledge of orthography.

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