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ORTHOGRAPHIC INFLUENCES ON INITIAL PHONEME ADDITION AND DELETION TASKS: THE EFFECT OF LEXICAL STATUS

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ABSTRACT

Here a study is conducted to examine orthographic effects on initial phoneme addition and deletion tasks with an adult population. The results of a previous study [1] with children suggest that the use of an orthographic strategy depends on lexical status, so two experiments were conducted, one with real words and the other with nonwords. In both experiments, some items were amenable to both an orthographic and phonological strategy, but the orthographic representations of the other items interfered with production of the correct response. Longer reaction times were found for interfering items in the real word tasks, but not in the nonword tasks. This result lends support to the idea that lexical access involves the automatic orthographic activation.

1. INTRODUCTION

Phoneme addition and deletion tasks have been used for decades as a measure phonological awareness. These are auditory tasks in which the participant is asked to add a sound to a word (addition), or remove a sound from a word (deletion). In a landmark study, Morais, Cary, Alegria and Bertelson [2] found that illiterate Portuguese participants made significantly more errors on these tasks than their literate counterparts. Reed, Zhang, Zie and Ding [3] conducted a replication with two groups of Chinese participants, both of whom were literate in Chinese characters, but one of the groups was also literate in a Mandarin alphabetic script. Reed et al. found the same difference as Morais et al. – the alphabetic literates performed better than did the non-alphabetic literates. Therefore, learning to read an alphabetic script leads to superior performance on phoneme addition and deletion tasks.

Morais et al. [2] claim that literacy leads to a knowledge that words consist of individual *sounds* and that this explains the superior performance of literates over illiterates. However, literates have the ability to use their knowledge of letters to manipulate the sounds in words and this may provide a more direct explanation for their superior performance. In other words, knowledge of phonemes may not be a necessary prerequisite for successful performance in phoneme addition and deletion tasks.

Stuart [1] conducted a phoneme deletion study with 9 year-old children to test whether any evidence for orthographic strategies can be found 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, and 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, which means that performance on the task may be similar to reading printed words aloud. According to dual-route models of reading [e.g., 4], printed strings of letters can be read aloud using stored representations or by using grapheme-to-phoneme correspondence rules. So, for real words, the spoken item could match onto a stored representation in the orthographic lexicon, the appropriate letter could be added or taken away, and the resultant string of letters “read aloud” to produce the response. For nonwords, the participants could construct an orthographic representation using phoneme-to-grapheme correspondence rules, and produce their response by the same method. Given this possibility that words and nonwords are processed differently in addition and deletion tasks, participants in the present study will be presented with either words or nonwords, but not both.

While Stuart’s [1] study clearly shows evidence for the existence of orthographic strategies in novice readers, it does not show whether the superior performance of adult alphabetic literates, on phoneme addition and deletion tasks, can be attributable to an orthographic strategy, rather than phonemic awareness. In other words, without instructions to the contrary, do alphabetically literates adults use their orthographic knowledge in phoneme addition and deletion tasks? Furthermore, if an orthographic strategy is apparent, is it restricted only to real word stimuli, where an internal orthographic representation is accessible, or can orthographic influences also be found in nonword tasks?

Stuart [1] used medial phoneme deletion, whereas Morais et al [2] and Reed et al. [3] used initial phoneme deletion and also phoneme addition. The present study seeks to be comparable with these latter two studies, so initial phoneme addition and deletion will be used. However, using initial phoneme addition and deletion, it is impossible to construct stimuli where the response clearly indicates the response strategy. Rather, stimuli will be selected which should interfere with performance on the tasks if an orthographic strategy is used. Longer reaction times (RTs) are predicted for those items. The method sections contain detailed descriptions of the stimuli for each experiment. The advantage of using RT data, rather than error data only, as in previous research [1-3], is that an influence of orthography can be observed even if the participant obtains correct answers for all items.

In summary, it is possible that the superior performance of adult alphabetic literates over illiterates is due not to phonological awareness *per se*, but to the availability of an orthographic strategy. It is hypothesised that participants will take longer to respond (and make more errors) to items where the orthographic representation interferes with the correct phonological response, than to non-interfering items, for both addition and deletion, and for both words and nonwords.

2. EXPERIMENT 1 – WORDS

2.1. Method

Participants and Design. The participants were 48 native Australian English speakers obtained from the Introduction to Psychology course at the University of Western Sydney, Australia. Half of the participants completed the addition task and the other half the deletion task. All participants reported having normal hearing.

The experiment was a single factor repeated measures design with two levels, “interfering” orthography and “non-interfering” orthography. There are no specific predictions about differences in performance on addition and deletion tasks, so their results were considered separately.

Stimuli and Apparatus. All stimuli were one-syllable English words obtained from the CELEX lexical database. 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”. The addition stimuli consisted of the same items in reverse. That is, the addition of /f/ to /ækt/ creates /fækt/. There were two types of stimuli in the experiment, “interfering” and “non-interfering”. For the non-interfering items, the addition or deletion could be successfully conducted using letters instead of sounds - adding the letter “f” to “act” 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” , and adding /k/ sound to /waɪt/ “white” makes /kwaɪt/ “quite”. In total, there were 36 items for addition and 36 for deletion, each set consisting of 18 inconsistent and 18 consistent items.

The stimuli were presented to the participants in random order as an instruction to add a sound to a word or take away a sound from a word, and the sound to be added or 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, to calculate the RT from the onset of the stimulus word in the instruction sentence.

Procedure. The experiment was conducted in a sound attenuated room. Participants sat on a stool, 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 with regards to the use of an orthographic or phonological strategy. Eleven non-interfering practice examples with feedback were followed by the 36 randomized experimental items with no feedback.

1.2. Results

Addition Task. The results for both addition and deletion are shown in Figure 1. Paired *t*-tests were used to compare consistent and inconsistent scores for each participant collapsed across items. There was a significant ($p<.05$) difference in RT to correct responses ($t(23)=3.45$), but not in number of errors ($t(23)=1.16$). 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. There was a significant difference for RT ($t(34)=1.83$), but not for errors ($t(34)=.75$).

Deletion Task. For the participant analysis, there was a significant ($p<.05$) difference in both RT to correct responses ($t(23)=5.52$), and to number of errors ($t(23)=3.50$). For the item analysis, there was a significant difference for RT ($t(34)=2.69$), but not for errors ($t(34)=1.65$).

3. EXPERIMENT 2 – NONWORDS

3.1. Method

Participants and Design. The participants were another 48 monolingual Australian English speakers from the same university course. Half completed the nonword addition task and the other half the nonword deletion task. All participants reported having normal hearing and the design of the experiment was the same as Experiment 1.

Stimulus Materials and Apparatus. All stimuli were one-syllable English nonwords where the addition of a phoneme to its beginning or the removal of its first phoneme resulted in a new nonword. For example, the removal of /d/ from /dwɪnt/ “dwint”, results in /wɪnt/ “wint” and the addition of /s/ to /wɒnθ/ “wonth” creates /swɒnθ/ “swonth”. Again, there were two types of stimuli, “interfering” and “non-interfering”. The interfering items were nonwords for which the use of an orthographic strategy, using regular spellings of the nonwords, would incorrectly result in the spelling for a real word. For example, removing the /s/ from /smɒnθ/ leaves /mɒnθ/, which is a nonword. However, removing the “s” from “smonth”, its regular spelling, leaves “month”, which is a real word with an irregular pronunciation. The

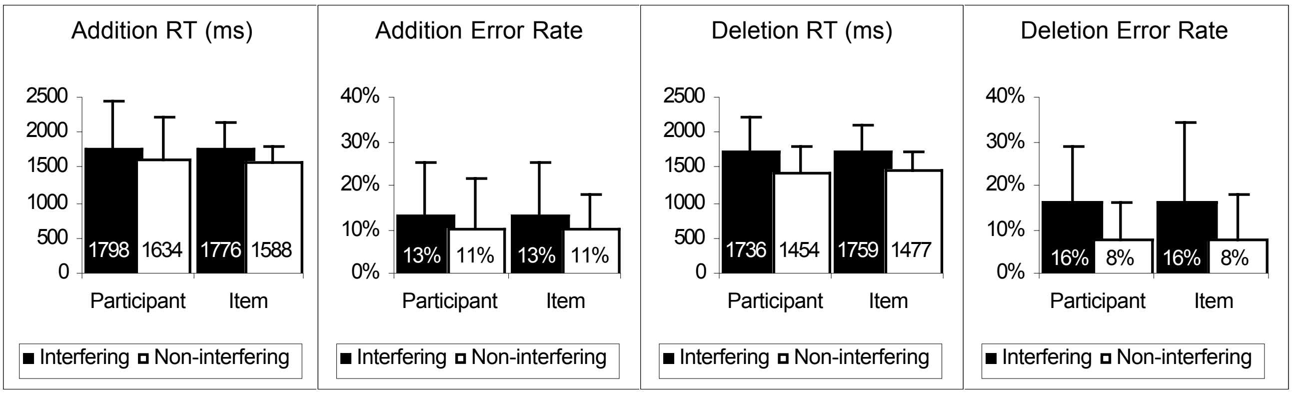

Figure 1: Reaction Times and error rates for addition and deletion in Experiment 1 collapsed across participants and items. Error bars represent standard deviations.

non-interfering items, on the other hand, were amenable to either a phonological or an orthographic strategy. There were 16 interfering and 16 non-interfering items for each task.

The interfering items were created by regularising the pronunciation of irregular words and adding or removing a sound. For example, the word "path" /pa:θ/ would be pronounced /pæθ/, using regular sound-spelling correspondences and there is no possible orthographic representation other than "path" for the string of phonemes /pæθ/. Thus, removing the /s/ "s" sound from /spæθ/ "spath" leaves /pæθ/ "path" and adding a /p/ "p" sound to /æθ/ "ath" makes /pæθ/ "path". Where possible, the non-interfering items were generated by shuffling the onsets and rimes of the interfering items to create different nonwords. The stimuli were prepared and presented to the participants in the same manner as Experiment 1.

Procedure. The procedure was the same as Experiment 1, except that after the experiment had finished, the participants were asked to listen to all of the instruction sentences again and type the spelling of the nonword stimulus. This was to ensure that the participant would have spelled the nonword with the intended spelling, had they used an orthographic strategy in the experiment.

3.2. Results

Spelling Task. For addition, the overall percentage of items spelled differently from the intended spelling was 25.7% (range: participants 0-50%, items 0-62.5%). There was no difference between interfering and non-interfering items for participants ($t(23)$=.98) or items ($t(30)$=.27). For deletion, the overall rate for items was 31.3% (range: participants 0-87.5%, items, 0-83.3%). There was no difference between interfering and non-interfering by participants ($t(23)$=0) or items ($t(30)$=0).

Due to the large number of spellings that were different from intended in some participants and for some items, the spelling data were used to exclude data from the RT and error analyses. First, participants were excluded if they did not spell more than two thirds of the nonwords with intended spelling. Second, items were excluded if less than two-thirds of the remaining participants spelled the item as intended.

Addition Task. The results for both addition and deletion are presented in Figure 2. After the exclusion of participants and items, there remained 18 participants, 13 interfering items, and 12 non-interfering items. For participants, there was no significant (p<.05) difference in RT ($t(17)$=.79) or error rate ($t(17)$=.70), which was the number incorrect (spoken) responses divided by the number of appropriately spelled items. The item analysis also failed to show significant results for RT ($t(23)$=.70) or error rate ($t(23)$=-.03)

Deletion Task. The exclusion of participants and items left 14 participants and 13 interfering and non-interfering items each for the analysis. For participants, there was no significant (p<.05) difference for RT ($t(13)$=-1.90) or for errors ($t(24)$=-1.27). However, there may be a difference in the opposite direction, as p>.96 for RT and p>.97 for errors. This trend was also reflected for items collapsed across participants for RT ($t(13)$=-1.27, p>.89) and for errors ($t(24)$=-.55, p>.71).

4. DISCUSSION

The results of Experiment 1 support the hypothesis. In both addition and deletion tasks, participants took longer to respond correctly to items with interfering orthographic representations. This suggests that when participants are given no specific instructions on how to perform these tasks, there is evidence for an influence of orthographic processing when the tasks involve real word stimuli. While these results provide no evidence against the notion that *phonological* awareness is necessary for these tasks, they suggest that other processes are active during the task. In Experiment 1, there were no clear differences between the error rates for interfering and non-interfering items, so it seems here that orthography simply interferes with other processes that are responsible for the production of the correct answer.

The hypothesis was not supported for Experiment 2. There was no evidence for longer RTs or more errors for interfering than non-interfering items in nonword addition, but there was a trend in the opposite direction for nonword deletion.

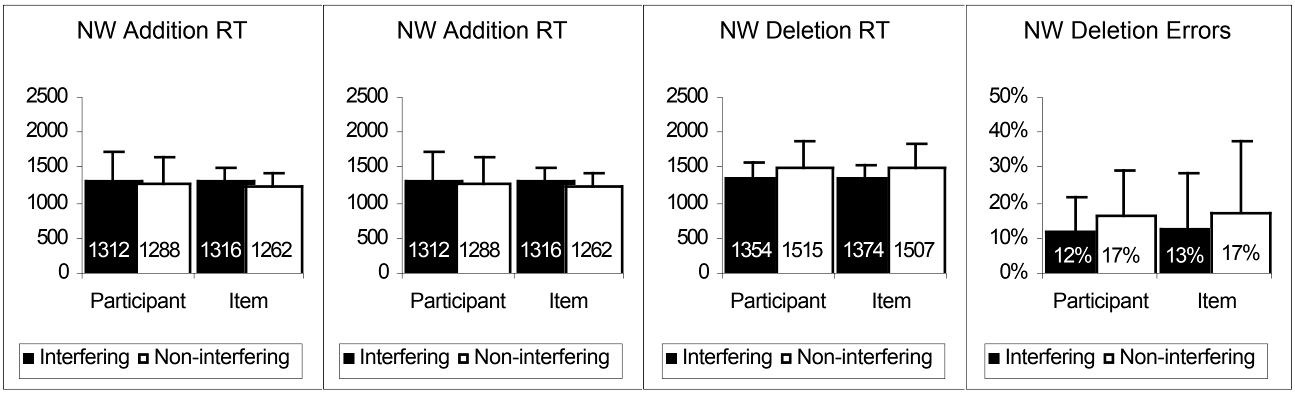

Figure 2: Reaction Times and error rates for addition and deletion in Experiment 2 collapsed across participants and items. Error bars represent standard deviations.

This means that in deletion, participants may actually respond more quickly when the orthographic representation of the nonword response is the same as a real word. If the interfering items do aid performance in the nonword task, perhaps this is because the embedded real words have irregular pronunciations. That is, when learning to read, people must learn that "month", "wolf" and "pint" are not "pronounced how they are spelled", so there may be latent activation for their regular pronunciations, which would lead to faster responding. If there is an orthographic effect for words but no effect for nonwords, as the addition data suggest, this would have implications for models of lexical storage. For example, Perin [5] 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 Experiment 1 the spelling for the interfering stimulus word may have been automatically activated, which inhibited the production of the correct response. To test this hypothesis, participants could be told prior to the experiment that an orthographic strategy would hinder their performance. If the orthographic activation is automatic, then slower RTs should still be obtained for interfering items. In Experiment 2, on the other hand, there was no stored representation because the stimuli were not real words. Even if the participants used orthographic processing, it would be via the phoneme-to-grapheme route, rather than the whole word route. As they were not processing their responses as real words, it is possible that they pronounced the irregular words (e.g. "month") as nonwords (/mɒnθ/) using grapheme-to-phoneme correspondence rules.

As the results of Experiment 2 are unclear, further experimentation is required to test the possibility that the orthographic interference observed in Experiment 1 is a function of lexical status. Using the items from Experiments 1 and 2, participants could be asked to perform a lexical decision on their addition or 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 than non-interfering items.

In summary, the results demonstrate that for literate, adult English speakers there is evidence for orthographic processing in phoneme addition and deletion tasks, at least when the stimuli are real words. In contrast to Stuart's [1] study, where a child's response pointed to 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 is not possible to ascertain whether phonemes or graphemes are responsible for the production of the correct answer. The results of Experiment 2 did not show same effect, suggesting that lexical access may play a role in the orthographic influence, but further studies need to be conducted to disambiguate the findings of this experiment. Therefore, while phonemic knowledge may be responsible for the superior performance of literates in the study of Morais et al. [2], the results of the present study demonstrate that further investigation is needed into alternative influences, such as the knowledge of orthography.

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