# No Influence of Articulatory Suppression on the Word and Pseudoword Superiority Effects

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## Abstract

In this study, we explored the role of phonological recoding in word and pseudoword superiority effects, previously characterized as pure orthographic effects. Participants were asked to identify letters embedded in briefly presented words, pseudowords, and nonwords with and without concurrent articulatory suppression. This manipulation had the purpose of occupying the participants' phonological loop and interfering with the phonological recoding of stimuli in working memory. We predicted that the presence of articulatory suppression would lower accuracy across stimuli and that this decrease would be more dramatic for pseudowords if participants relied on phonological recoding to perform the task. Word and pseudoword effects were present in both conditions; furthermore, articulatory suppression caused a similar decrease in accuracy for the three types of stimuli. Therefore, word and pseudoword superiority effects were not affected by the lack of phonological recoding. These results suggest that these effects mainly reflect orthographic processing.

## Introduction

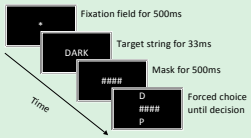
Orthography refers to the specific set of alphabetic symbols and letter combinations that characterize the arrangement of letters into sequences according to specific combinatorial rules of the language (Grainger, Bouttevin, Truc, Bastien, & Ziegler, 2003; Grossi Murphy, & Boggan, in press; McClelland, 1976).

Research has show that the processing of orthographic information is an important aspect of the word recognition process (e.g., Besner, Smith, & MacLeod, 1990). One of the tasks employed to measure orthographic processes is the Reicher-Wheeler task.

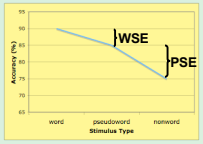
### Reicher-Wheeler Task

Reicher (1969) and Wheeler(1970) devised a task to measure the contribution of orthographic processes in reading in identification of letters in isolation (DXXX) and letters in context (DARK).

In their paradigm a string of letters is presented briefly, then masked. Participants must then identify the letter presented in the previous stimulus in a given position. Reicher and Wheeler showed that letter identification is contextual: it is optimal when letters are embedded in words compared to isolation or illegal letter strings.




### Word Superiority Effect & Pseudoword Superiority Effect




**Word Superiority Effect (WSE)**: Participants are more accurate with words compared to pseudowords (e.g., LAPE) [considered an index of familiarity with the words of a language]

**Pseudoword Superiority Effect (PSE)**: participants are more accurate with pseudowords compared to nonwords (e.g., XQRF) [considered an index of familiarity with the orthography of a language]

### Phonology & Reading

Orthographic and phonological processes are intimately related (McClelland, 1976; Baron & Thurston, 1973). **Phonological decoding**, a slow and sequential process by which graphemes are mapped onto their corresponding phonemes, is a critical tool in reading development (Alario, De Cara, & Ziegler, 2007) and provides a self-teaching device that allows children to decode novel words (Ziegler & Goswami, 2005).

## Purpose of the Study

Do word and pseudoword superiority effects reflect pure orthographic processes? Or they partially reflect the involvement of phonological processing?

Grainger et al. (2003) tested the WSE & PSE in dyslexic children with marked phonological deficits. The data failed to show significant differences between dyslexic children and control children for the PSE.

Following in the vein of Grainger et al. (2003), we directly tested the role of phonology in WSE and PSE by employing an articulatory suppression paradigm aimed at preventing phonological recoding of the stimuli in working memory.

### Articulatory Suppression

In articulatory suppression tasks, participants articulate irrelevant material while performing a particular task, for example learning or processing written material. In Baddeley's model of working memory (Baddeley, 1986), concurrent articulation negatively impairs accuracy in recall by preventing the stimuli from being recoded phonologically into working memory. According to the model, the articulatory control process, based on inner speech, converts written material into a phonological representation and registers it in the phonological store.

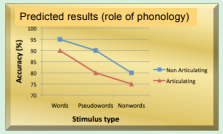
## Predictions

Participants were asked to perform a forced-choice letter identification task (the Reicher-Wheeler paradigm) with and without articulatory suppression. Based on previous research, we hypothesized that articulatory suppression would tax the phonological loop and prevent the stimuli from being recoded phonologically into working memory. The following predictions were made:

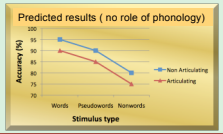
**Prediction 1.**
Reicher-Wheeler task without articulatory suppression (control task): Based on previous research, we expected to observe both the WSE and the PSE.

**Prediction 2.**
The presence of articulatory suppression would lower accuracy across stimuli compared to the control task (Broadbent, 1982; Pashler, 1994). Given that illegal nonwords were unlikely to be coded phonologically, we considered the decrease in accuracy with nonwords an estimate of a general interference effect due to the presence of a secondary task.

**Prediction 3.**
***If phonology plays a role*** in the Reicher-Wheeler task (participants rely on phonological recoding to perform the letter identification task): We assumed that accuracy should decrease more dramatically for pseudowords than words and nonwords. Pseudowords are more likely to be processed phonologically than real words (which can be processed semantically or lexically) and nonwords (for which a phonological representation is not available) (Papagno & Vallar, 1992).




However, ***if phonology does not play a role*** in the Reicher-Wheeler task: We would expect words, pseudowords, and nonwords be equally impacted by articulatory suppression (right).




## Methods

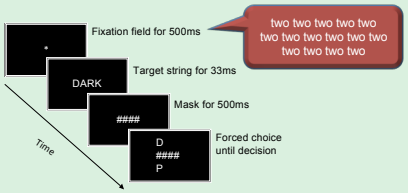
*Participants.* Twenty-five 25 students (8 males; mean age: 21, range: 19-29) participated in the study.

*Stimuli.* Four-letter words and pseudowords were selected from Chase and Tallal (1990). Words had a written frequency of 12 or more per million (Kucera and Francis, 1967).

| | Word | Pseudo word | Nonword |
|---|---|---|---|
| List 1 | DARK | DARB | DRKW |
| List 2 | PARK | PARB | PRKW |

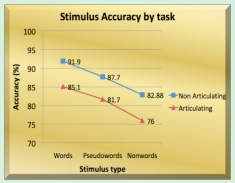
Words that differed by a single letter position were selected as word pairs. Forty word pairs were chosen, 10 pairs for each letter position (e.g., DARK-PARK, LOVE-LIVE, LIFE-LIKE, MILE-MILK). Pseudowords that matched each pair of words were constructed by (most often) changing the letter most distant form the target letter to produce a pronounceable nonword (e.g., DARB-PARB). Nonwords were constructed by substituting consonants for vowels, and rearranging the letters of the corresponding words.

*Procedure.* Subjects were randomly assigned to the articulating or non-articulating condition first of the Reicher-Wheeler task. Each condition included 120 trials. In the articulation condition, subjects were prompted with a metronome to repeat the word "two" twice a second until they pressed one of two buttons on a keypad (indicating which letter appeared in the previous stimulus in a given position).




## Results

A two-way within-subjects analysis of variance assessed the role of task (control, articulatory suppression) and stimulus type (word, pseudoword, nonwords) on participants' accuracy. Word and pseudoword superiority effects in the two conditions were assessed by separate two-way analyses of variance.




**Prediction 1.**
Stimulus type was significant as main effect ($F(2,48)=21.01$, $p<.0001$). Planned comparisons revealed that participants were more accurate with words (mean=91.90, SD=9.69) as compared to pseudowords (mean=87.70, SD=10.20) (WSE, $t(24)=3.83$, $p=.001$, two-tailed); similarly, participants were more accurate with pseudowords as compared to nonwords (mean=82.88, SD=9.20) (PSE, $t(24)=3.53$, $p=.002$, two-tailed) in the control condition.

**Prediction 2.**
The omnibus ANOVA revealed that task was a significant main effect ($F(1,24)=20.21$, $p<.0001$): participants were more accurate in the control compared to the experimental task (mean=87.33, SD=8.85; mean=80.53, SD=11.17, respectively).

**Prediction 3.**
Task did not interact with stimulus type ($F(2,48)=.02$, $p=.978$, n.s.). The decrease in accuracy due to articulatory suppression was similar for the three stimulus conditions (6.8%, 6%, 6.88% for words, pseudowords and nonwords, respectively). WSE and PSE were also present in the articulatory suppression task: stimulus type was significant as main effect ($F(2,48)=8.70$, $p=.002$). Planned comparisons revealed that participants were more accurate with words (mean=85.10, SD=13.02) compared with pseudowords (mean=81.70, SD=12.31) (WSE, $t(24)=2.38$, $p=.026$, two-tailed); similarly, participants were more accurate with pseudowords compared with nonwords (mean=76.00, SD=11.86) (PSE, $t(24)=3.13$, $p=.005$, two-tailed).

## Conclusion & Discussion

• Words and pseudowords superiority effects were present in the control condition. Therefore, our data confirm the robustness of both superiority effects across a variety of stimuli and languages (Chase & Tallal, 1990; Grainger et al., 2003; Grossi et al., in press).

• Articulatory suppression proved to be a effective secondary task and lowered participants' accuracy. This effect replicates previous data (e.g., Broadbent, 1982; Pashler, 1994) showing attentional limitations during the performance of concurrent multiple tasks.

• The decrease in accuracy due to articulatory suppression was similar for the three types of stimuli. Moreover, both WSE and PSE were present in the articulatory suppression condition. Therefore, the present results suggest that interfering with the phonological recoding of stimuli in the letter identification task does not affect the WSE and the PSE. We conclude that these two effects can be considered indices of familiarity with the words and the orthography of a language, respectively (Grainger et al., 2003) and do not seem to reflect phonological processes, at least those dependent on articulation.

• Research employing rapid presentation tasks that shows that phonological representation of stimuli are automatically activated during reading even in the absence of awareness (e.g., Booth, Perfetti, & MacWhinney, 1999; Ferrand & Grainger, 1992). Another possibility is that, in the present task, phonological representations not reflecting articulatory mechanisms were activated. This possibility will be tested by employing a phonological interference task.

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