

Department of Psychology and Education

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May 2006

The Effects of Orthography and Phonology
on Vocabulary Acquisition

by
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TABLE OF CONTENTS

	Page
Acknowledgements	iii
List of Figures	vii
List of Tables	viii
Abstract	ix
Introduction	1
The Role of Context in Vocabulary Acquisition	1
Orthography and Phonology	6
Dual-route Theory	6
Evidence for Phonological Coding	8
Evidence for Orthographic Coding	12
Differences between Skilled and Less Skilled Readers.	14
The Present Experiment	16
Method.	19
Participants	19
Materials	19
Stimuli.	19
Sentence Frames.	24

Vocabulary Test	24
Nelson Denny Reading Test	26
Questionnaire	26
Apparatus	26
Procedure	27
Results	30
Initial processing of the target word	30
Reanalysis of the target word	32
Initial processing of the informative context	41
Reanalysis of the informative context	41
Initial processing of the category word	47
Reanalysis of the category word	50
Vocabulary Test Scores	56
Lexical Decision Task	63
Discussion	69
Present Results Compared to Predicted Outcome	69
Directions for Future Research	73
Conclusion	74
References	76

Appendix A. Orthographic, Phonological, Neutral and Familiar Conditions	79
Appendix B. Experimental Sentences with Orthographic, Phonological, Neutral and Familiar Target Words	81
Appendix C. Filler Sentences	92
Appendix D. Questionnaire	94
Appendix E. ANOVA Tables	95

LIST OF FIGURES

	Page
<i>Figure 1.</i> The initial processing time (mean milliseconds \pm SEM) for the target word region of the sentence.	33
<i>Figure 2.</i> The total time, spill over time, and second pass time (mean milliseconds \pm SEM) for the target word region of the sentence.	37
<i>Figure 3.</i> The number of regressions (mean \pm SEM) for the target word region of the sentence.	39
<i>Figure 4.</i> The initial processing time (mean milliseconds \pm SEM) for the informative context region of the sentence.	42
<i>Figure 5.</i> The total time, spill over time, and second pass time (mean milliseconds \pm SEM) for the informative context region of the sentence.	45
<i>Figure 6.</i> The number of regressions (mean \pm SEM) for the informative context region of the sentence.	48
<i>Figure 7.</i> The initial processing time (mean milliseconds \pm SEM)] for the category word region of the sentence.	51

LIST OF TABLES

	Page
<i>Table 1.</i> Analysis of variance for first fixation duration (mean milliseconds \pm <i>SEM</i>) for the target word.	31
<i>Table 2.</i> Analysis of variance for total time (mean milliseconds \pm <i>SEM</i>) for the target word.	35
<i>Table 3.</i> Analysis of variance for regressions for the target word region of the sentence.	36
<i>Table 4.</i> Analysis of variance for initial processing time (milliseconds) for the informative context region of the sentence.	44
<i>Table 5.</i> Analysis of variance for total time (milliseconds) for the informative context region of the sentence.	53
<i>Table 6.</i> Analysis of variance for regressions for the informative context region of the sentence.	55
<i>Table 7.</i> Analysis of variance for initial processing time (milliseconds) for the category word region of the sentence.	58

ABSTRACT

The purpose of this study was to examine whether orthographic and phonological properties of nonwords facilitate or inhibit vocabulary acquisition in adult skilled readers. Participants' eye movements were measured as they read a series of sentence pairs containing either a familiar word or a nonword. There were three conditions for the nonwords: orthographic, phonological and neutral. The orthographic nonwords were created by changing one letter of a real word. The phonological nonwords sounded like a real word but had a different spelling. The neutral nonwords did not closely resemble real words in both spelling and pronunciation. Data were analyzed on participants' eye movements and performance on a vocabulary test. It was predicted that the processing times and number of regressions back to the target word would be highest for the phonological condition followed by the orthographic and neutral conditions. However, no differences were found for initial processing times. This finding does not support the prediction that phonology is activated early in word processing. There were some significant differences in the rereading times. Some of these findings suggest that orthography and phonology both play a role in word processing. The results may be explained by word recognition models.

INTRODUCTION

It is essential for readers to be able to understand the meanings of a wide range of printed words while reading. Although vocabulary growth estimates vary widely, it is clear vocabulary acquisition is an important skill considering the high number of uncommon words that occur in text (Morris & Williams, 2003).

Unfamiliar words can be learned through various methods ranging from formal instruction to reliance on contextual information. Some researchers have suggested that deciphering meanings of unfamiliar words through the use of context is a common method of vocabulary acquisition (Morris & Williams, 2003). However, there has not been a large amount of research on the processes involved in gaining new vocabulary in this way.

The Role of Context in Vocabulary Acquisition

Researchers have conducted eye movement studies to examine the role of contextual information on vocabulary acquisition. Chaffin, Morris and Seely (2001) investigated how college students use context to determine the meaning of unfamiliar words. In Experiment 1, participants read sentences that included either a high-familiar, low-familiar, or novel word followed by informative context. A second sentence contained a category word that provided information about the general category to which the word belongs (e.g., a musical instrument). The researchers used an eye tracker to measure eye movements as the participants

read the target word, the context, and the category word in the second sentence. When participants read a sentence containing a novel word, they spent a longer amount of time gazing at the context following it than they did for the high- and low-familiar words. For example, when participants read the sentence, "Joe picked up the asdor and began to strum a tune," they spent more time processing the informative phrase "strum a tune" than they did when "asdor" was replaced by the word "guitar" (high-familiar) or "zither" (low-familiar). The researchers also analyzed regressions into the target word, which refers to the number of times the reader looked back to the target word after first leaving the target word region. Participants were more likely to make regressions into the target word when it was a novel word compared to a high- or low-familiar word. Processing time for Sentence 2 did not differ among conditions, which suggests that readers already established the meaning of the target word before their eyes left Sentence 1. The researchers concluded that, based on this experiment, participants were able to effectively use context to deduce the meanings of the novel words while reading silently.

Experiment 2 of Chaffin et al.'s study provided further support for this idea that readers tend to focus on the most informative regions of the text in order to learn new words efficiently. The informativeness of the context in the first sentence was varied in order to examine whether participants would spend the same amount of time processing informative and uninformative context. This

manipulation also allowed the researchers to determine whether or not participants realized that Sentence 1 and Sentence 2 both referred to the same object. Data from the novel–neutral condition showed that participants relied on the synonym in Sentence 2 to help determine the meaning of the target word. The first sentence in the novel-neutral condition contained a novel word surrounded by neutral context. An example of a sentence pair in this condition is "Joe picked up the asdor and began to walk home," followed by "He played the instrument to relax." Participants who viewed this version of the sentence pair knew that the synonym embedded in the second sentence (in this case, "instrument") referred to the target word in the first sentence ("asdor"). This supports the conclusions in Experiment 1 and shows readers were able to identify the areas of the text that would facilitate comprehension.

Initial and total processing times, as well as the number of regressions, were higher in the novel word conditions than in the familiar word conditions. Initial processing times were measured by first fixation and gaze duration. First fixation refers to the amount of time spent on the first fixation of a word, regardless of the total number of fixations made on that word. Gaze duration includes all of the fixations made by the reader before she leaves the word or region. In the novel-full context condition, readers spent a longer time gazing at the contextual information than they did in the novel-neutral context condition. The novel-full context condition contained both the novel word and the

informative context in the first sentence, as in "Joe picked up the asdor and began to strum a tune." The difference in processing time between the conditions indicates that readers recognized that the novel-full context condition contained more informative text, and they consequently spent more time processing it. This study strongly supports the notion that readers do in fact pay closer attention to informative context than to uninformative context.

Williams and Morris (2004) also conducted an eye movement study investigating the effects of word familiarity. From the eye movement data, they found that the initial processing times were longer for the novel and low-familiar words than for the familiar words. Chaffin et al. (2001) also found that less initial time was spent on high-familiar words, although they did not find a difference between novel and low-familiar words. Williams and Morris explain this inconsistency by describing the differences in the procedures used in the studies. The familiarity ratings utilized by Williams and Morris were higher than those used by Chaffin et al. This suggests that the participants in Chaffin et al.'s study may not have been familiar with the low-familiar words. In addition to examining on-line processing, Williams and Morris also administered a vocabulary test to determine how well participants retained the semantic meanings of the target words. The results of this test showed that readers learned the meanings of the unfamiliar words they encountered during the study.

Williams (2004) provided further evidence that readers are able to effectively use contextual information to determine the meanings of unfamiliar words. In the study, familiar words (e.g., "banjo") and nonwords (e.g., "asdor") were embedded into sentences that began with either semantically constraining text or neutral text. An example of a sentence in the semantically constraining condition was, "Joe began to strum a tune on the asdor that he carried." From the eye movement data, the researcher found that readers spent less time processing the nonwords when the informative context was in the beginning of the sentence than when it was located at the end of the sentence. It was also found that readers spent less time processing familiar words than unfamiliar words. This is consistent with past research (e.g., Chaffin et al., 2001; Williams & Morris, 2004).

In addition to examining the role of context and word familiarity, Williams investigated whether reader characteristics such as vocabulary knowledge influence how readers process unfamiliar words. Data analyses indicated that readers with a higher level of vocabulary knowledge spent less time processing both unfamiliar and familiar words than readers who had less vocabulary knowledge. It was also found that readers with less vocabulary knowledge spent less time rereading unfamiliar words when the informative context was in the beginning of the sentence than when it was located at the end. This suggests that readers with less vocabulary knowledge found it easier to learn

the meanings of unfamiliar words when informative context is located at the beginning of a sentence. Information from a vocabulary test administered after the reading task indicated that all readers successfully learned the meanings of the unfamiliar words using context.

Orthography and Phonology

While research has been conducted regarding how readers use context to learn new words, researchers have not been as concerned with examining the properties of the unfamiliar words. The ease with which a reader can determine the meaning of an unfamiliar word may depend upon the phonological and orthographic properties of the word. Phonology relates to pronunciation, while orthography refers to spelling. There is a debate regarding the roles of these two sources of information in word processing. While some researchers have proposed that the visual-orthographic route is centrally involved (e.g., Daneman & Reingold, 1993; Daneman, Reingold & Davidson, 1995) others argue for the importance of phonological coding (e.g., Folk, 1999; Rayner, Pollatsek & Binder, 1998; Van Orden, 1987).

Dual-route Theory

Dual-route theory asserts that orthography is the central route by which readers retrieve the meanings of words. According to this theory, there are two methods that readers can use when identifying words. In the first method, the reader uses the lexical route to access the word's meaning. This process can only

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METHOD

Participants

Twenty-two students from Mount Holyoke College were recruited to participate in the eye tracking task in exchange for credit toward the research participation requirement of their psychology courses. Students not enrolled in a psychology course that grants this credit were offered \$10 to participate. Participants were recruited through sign-up sheets, flyers, email, and word-of-mouth. All participants had normal or corrected-to-normal vision. Seventeen of the participants reported English as their first language, while 5 participants did not.

In addition to the eye tracking task, 55 students from Mount Holyoke College completed a lexical decision task. These participants were recruited and rewarded in the same manner as the participants in the eye tracking task. Of these participants, 41 indicated that English was their first language, 13 reported that it was not, and 1 participant reported learning English simultaneously with another language.

Materials

Stimuli. Thirty-six four-to-nine-letter nonwords were selected for each of the three nonword conditions (see Appendix A). In addition, 54 familiar words were selected. Participants were shown either a nonword or a familiar word for

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RESULTS

For the eye movement data, three regions were analyzed: the target word, the informative context in Sentence 1, and the definitional associate of the target word in Sentence 2. Data from one of the twenty-two participants were not analyzed due to track losses. The data were analyzed using SPSS 12.0. The design was a one-way ANOVA, and the levels of the independent variable were the orthographic, phonological, neutral and familiar word conditions. An alpha level of .05 was used for all statistical tests. For each measure with a significant effect, an LSD post-hoc test was conducted. Appendix E contains ANOVA tables for all of the measures.

Initial Processing of the Target Word

Initial processing time was measured by examining first fixation duration and gaze duration. First fixation refers to how long the participant spends in the first fixation on the word; it does not matter how many times the participant has fixated the word. Gaze duration is the total amount of time spent fixating on a target word spanning from when the participant first set her gaze on that word or region to when she first leaves it. This is called first pass reading time when referring to a region with multiple words.

As shown in Figure 1, the mean first fixation duration is highest for the orthographic target words, followed by the phonological, neutral, and familiar

Table 1.

Analysis of Variance for First Fixation Duration for Target Word

Source	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>
Target	11868.86	3	3956.29	1.33	0.27
Error	178996.64	60	2983.28		

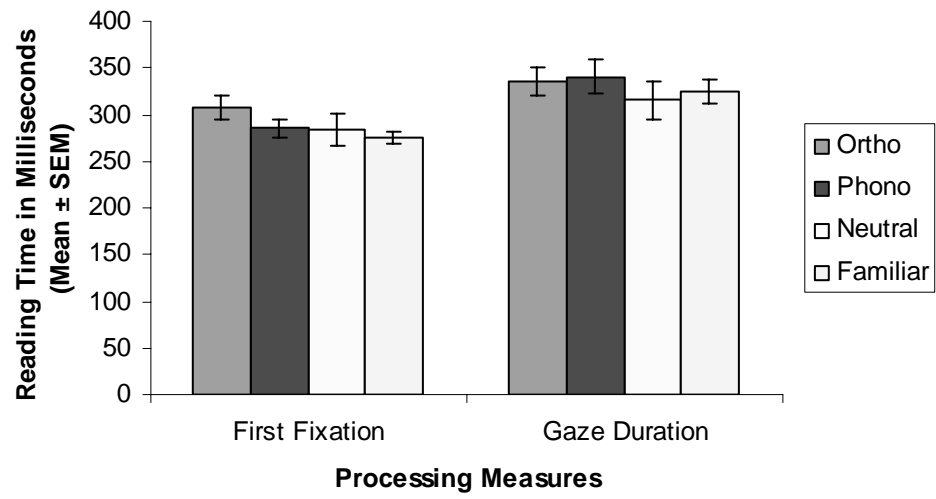
targets. However, no main effect was found for first fixation, $F(3, 60) = 1.33$, $MSE = 2,375$, $p > .05$.

Also shown in Figure 1, the mean gaze duration is highest for the phonological target words, followed by the orthographic, familiar and neutral target words. There was no main effect for gaze duration, $F(3, 60) = .51$, $MSE = 6,160$, $p > .05$ (see Table 2). The failure to find significance for the first fixation and gaze duration measures indicates that participants did not differ significantly in the initial time they spent on the target words. This is inconsistent with past research that has found longer initial processing times for nonwords than for high-familiar words (e.g., Chaffin et al., 2001; Williams, 2004; Williams & Morris, 2004).

Reanalysis of the Target Word

Total time, spill over, second pass time, and regressions were used as rereading measures. The total time includes the amount of time spent on all fixations in the region, including the time spent rereading. Spill over is the amount of time spent on the fixation that comes directly after the participant stops looking at the word. This is believed to reflect post-access processes. If the item is more difficult to process, the spill over time should be longer. Second pass time refers to how long the reader spends looking at the word after leaving it and coming back to it a second time. Regressions out of the target region were followed by a fixation to an earlier point in the sentence. Regressions into the

Figure 1. The initial processing time (mean milliseconds \pm SEM) for the target word region of the sentence.



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DISCUSSION

The present study examined whether the orthographic and phonological properties of nonwords facilitate or inhibit vocabulary acquisition. Participants' eye movements were monitored as they read fifty-four sentences, each containing a familiar word or an orthographic, phonological, or neutral nonword. The phonological nonwords were expected to cause the most difficulty for skilled readers. The neutral nonwords were predicted to be less difficult than the orthographic and phonological items because seeing them should not activate any real words. To determine if the hypothesis was supported, three regions of the items were examined: the target word, the informative context, and the category word. The results were not entirely consistent with our hypothesis. No significant differences were found in the initial processing of the three regions, which does not support our prediction that phonology is activated early in word processing. However, evidence for both phonological and orthographic processing was found in some of the reanalysis measures.

Present Results Compared to Predicted Outcome

Participants spent more total time on the orthographic and phonological target words than on the familiar target words. The total time was also higher for the phonological target words compared to the neutral items. These findings suggest that the orthographic and phonological items caused interference for the

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Appendix A

Orthographic, Phonological, Neutral and Familiar Conditions

Source Words	Orthographic	Phonological	Neutral	Familiar
ballroom	ballkoom	bawlrume	quintrod	champagne
brain	Briar	Brayne	asdor	salt
broccoli	broscoli	brockalee	spocheld	apricots
broom	Broam	Brume	swurp	onions
camera	cameda	kamarah	lathlar	pistol
choir	Thoir	Kwire	troig	roses
city	Oity	Sitee	nilb	house
clerk	Clerf	Klurck	ginta	hymn
clock	Closk	Klawk	ploje	guitar
coffee	cogfee	Kophy	quetic	knife
cousin	comsin	Kuhzen	zithen	baseball
disk	Disp	Dihsk	keth	chairs
doctor	dootor	Dahktur	klendop	radio
dollar	Dollan	dawlur	crauth	dress
friend	Friond	Phrynd	joart	leather
fruit	Fruit	Phroot	mugro	wrench
garden	gamden	Gaurdyn	brensot	cocktail
human	humak	Huemyn	noalt	church
kitten	Kiften	Kyttin	seloip	yacht
lawyer	mawyer	Loyur	cudram	needle
milk	Misk	Mihlck	phup	taxi
mirror	mirsor	Meerur	secain	hawk
money	Motey	Munnee	pexim	water
ocean	Ocead	oshun	plarp	waltz
oxygen	oxylen	ocksijen	rickep	cabbage
paper	Paped	Paypur	hulto	rolls
phone	Plone	Foane	sodet	salmon
picture	picqure	Pikshir	flipins	science