Applying the Self-Teaching Hypothesis to Adults:
The Effects of Reading Condition and Syllable Length on Orthographic Learning

by

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An orthographic learning protocol was used to test whether the self-teaching hypothesis (Share, 1995) applies to adults. The self-teaching hypothesis posits that readers can independently use phonological recoding to achieve skilled recognition of unfamiliar printed words. Eighteen Native English-speaking adults read short stories that contained unfamiliar target pseudowords either aloud or silently. The pseudowords were either monosyllabic or multisyllabic. The amount of orthographic learning was tested one week later with two posttests. It was predicted that adults would perform similarly as children, since the self-teaching hypothesis asserts that decoding remains a fundamental mechanism for orthographic learning across all stages of reading development. As expected, the results revealed that decoding ability is positively correlated with orthographic learning. However, we found stronger orthographic learning as measured by an Orthographic Choice task when adults read aloud, as compared to silently. We also found stronger learning as measured by a Spelling task when adults learn monosyllabic items. We conclude that adults make greater use of lexicalized decoding, which draws upon visual similarities between new and already learned words, than the letter-sound decoding used by beginning readers. Further, we hypothesize that silent reading promotes the use of lexicalized decoding whereas reading aloud stimulates both beginner decoding and lexicalized decoding. Unobserved in children, these findings suggest that orthographic learning occurs in adults but it involves a different mix of decoding strategies than seen in children.

Keywords: Self-teaching; phonological recoding; adult orthographic learning; printed-word acquisition; silent reading

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1.0 INTRODUCTION

While many people can succeed under the current reading instruction system, those who struggle under this system develop poor reading skills. This can often lead to social and occupational disabilities, and we cannot address this issue without understanding the mechanisms of reading acquisition. Testing theories on the learning mechanisms that underlie the development of skilled reading serves as a gateway toward improved reading instruction and enhances reading theory.

One prominent theory about reading development is David Share's self-teaching hypothesis (1995). Share proposed the idea that reading development is based on continued and successful phonological recoding. Phonological recoding (also referred to as decoding) is a process in which readers connect unfamiliar printed word forms with sound and meaning. Every time an unfamiliar printed word is successfully decoded, a reader is presented with an opportunity to achieve skilled recognition of the printed word. In beginning readers, letter-to-sound knowledge is used to translate unfamiliar printed words into the spoken form. As readers advance in skill, the decoding process changes and is said to became 'lexicalized.' Lexicalized decoding allows readers to rely less on breaking each word down according to letter-to-sound knowledge and more on the visual pattern of words. This advanced decoding mechanism encourages readers to learn printed words more holistically while using phonology, or the spoken translation of the printed words, as an underlying tool.

The self-teaching hypothesis (Share, 1995) is important because it explains how learning can occur without direct instruction from others (e.g., parents or teachers). With decoding, beginning readers can rely on their own letter-to-sound knowledge to gain orthographic knowledge about the visual forms of unfamiliar printed words. Importantly, Share's theory posits that advanced readers also rely on decoding for orthographic learning, although they can use their already existing orthographic knowledge to more easily decode unfamiliar words that are visually similar to already learned words. In summary, Share's theory explains how both children and adults use decoding to bootstrap their orthographic learning of unfamiliar printed words.

Orthographic learning protocols have been used to test Share's theory. A typical protocol has a learning phase in which participants read unfamiliar but pronounceable English non-words (pseudowords), and a subsequent testing phase in which the strength of orthographic learning is measured. Two tasks have been widely used to measure orthographic learning: an Orthographic Choice task and a Spelling task. In a typical Orthographic Choice task, participants are presented with the orthographic form of a recently experienced pseudoword (the target) and a homophone, which is an alternative spelling of the same spoken word (e.g., *meep* and *meap*). They are then instructed to choose the pseudoword that is more familiar to them. In the Spelling task, a recently experienced pseudoword is spoken aloud by an experimenter and participants are asked to spell it to the best of their abilities.

The self-teaching hypothesis (Share, 1995) has been tested in grade school children and there is significant evidence suggesting that phonological recoding directly leads to orthographic learning (e.g., Cunningham, Perry, Stanovich & Share, 2002; Kyte & Johnson 2006; Nation, Angell & Castles, 2007; Ricketts, Bishop, Pimperton & Nation, 2011; Share, 1999, 2004). In most of these past studies, children were asked to read aloud pronounceable pseudowords in order to stimulate phonological recoding. These pseudowords were analogous to unfamiliar words encountered by readers in real life. After a delay of a few hours to a few months, posttests that measured the level of orthographic learning were administered. Children showed orthographic learning by choosing the target spelling over the homophone spelling in an Orthographic Choice task and correctly reproducing the target spelling more so than the homophone or other spellings.

Experimental learning conditions do not always match natural learning conditions. Independent learning described by Share (1995) is best simulated with a silent reading condition because readers have the most opportunities to read silently (Bowey & Muller, 2005). To investigate whether phonological recoding occurs under silent reading conditions, de Jong and Share (2007) directly manipulated the speech production conditions under which children decoded novel monosyllabic pseudowords embedded in experimental stories. In their study, children either read stories aloud or silently. Three or four days later, the children completed an orthographic choice test involving the previously read items and novel homophone spellings of the target items. They were instructed to circle the item they recognized from the story reading. Children also completed a spelling test of the read items where they were instructed to reproduce on paper the words they read previously. In addition, children completed a naming task where they read aloud a set of words including both the previously read items and the novel homophone spellings used in the Orthographic Choice task. In all three tests of orthographic learning, de Jong and Share reported above chance target accuracy, which indicated orthographic learning occurred; however, they did not report significant performance differences for items learned under the read aloud or silent conditions. De Jong and Share concluded that decoding occurs in silent reading and showed that decoding ability is directly correlated with performance on the Orthographic Choice task.

Although there exist robust studies of orthographic learning in children, there are few studies of orthographic learning in adults. Since Share (1995) posited that decoding persists into adulthood, it is important to test the self-teaching hypothesis in adults as well as children. Two studies developed orthographic learning protocols to test Share's theory in adults. Chalmers and Burt (2008), in their third experiment, provided a test of natural adult phonological recoding by investigating orthographically complex multisyllabic pseudowords in a silent reading condition. While the pseudowords used in children's studies of orthographic learning are mostly monosyllabic to reflect the level of reading children have attained, Chalmers and Burt reasoned that literate adults have greater word knowledge than children, and the unfamiliar words they encounter are often orthographically complex and unfamiliar both in sight and sound. Their idea showed the importance of using multisyllabic pseudowords to test orthographic learning in adults. In their third experiment, they manipulated the encoding conditions in which pseudowords were processed in learning. In the orthographic encoding condition, participants were instructed to count the consonant clusters. In the phonological encoding condition, participants were instructed to indicate whether the target letter was presented in the stressed syllable. The participants then read definitions for the pseudowords silently after encoding in both conditions. Chalmers and Burt then administered an Orthographic Choice task and a cued Spelling task. In the cued Spelling task, the first three letters were provided to aid adults in spelling. In their third experiment, they concluded that when independently learning without direct instructions, orthographic learning is superior when participants used phonological processing compared to orthographic processing. The results thus align with Share's self-teaching hypothesis but the experiment did not follow the typical design of an orthographic learning protocol.

Another adult study by Burt and Blackwell (2008) more closely resemble a typical study of orthographic learning, although it was designed to test competing models of spelling acquisition. In a training phase, participants were instructed to read aloud pseudowords on a screen and were provided with the meaning of each pseudoword. After completing training, participants were immediately tested with a vocal Spelling task in which they were instructed to say aloud the studied spellings. Burt and Blackwell reported that the pseudowords that were read aloud faster during training were more accurately spelled in the vocal Spelling task. They explained this finding with Share's self-teaching hypothesis, claiming that faster reading during training is equivalent to better decoding abilities. However, this was not how studies of orthographic learning in children measured decoding ability. Even though their study showed evidence of learning based on high accuracies in vocal spelling, because Burt and Blackwell were studying spelling theories, they did not manipulate factors that have been of most interest within the orthographic learning literature. However, one interesting addition is that their results demonstrate that it is not necessary to use multisyllabic pseudowords to observe evidence of orthographic learning in adults.

In summary, although both of the prior studies in adults provide evidence for orthographic learning in adults, they used learning and testing conditions that cannot be readily compared to prior studies involving children. This makes it difficult to determine how well the self-teaching hypothesis generalizes across different stages of reading development. Further, the studies leave open the question of whether the strength of orthographic learning depends upon the syllabic length of the pseudowords. The current study is designed with these issues in mind.

It examines orthographic learning in adults by testing the use of decoding in undergraduate students through story reading. During the learning session on the first day of testing, participants will be asked to read short stories under two experimental conditions: a read aloud condition that promotes the use of decoding and a silent reading condition that simulates natural independent reading. In the stories, we will embed pseudowords that are either monosyllabic or multisyllabic. Orthographic learning will be evaluated in a testing session seven days after the learning session with an Orthographic Choice task and a Spelling task. If adult orthographic learning is similar to that observed in children, no main effect of Reading Condition (read aloud or silent reading) should be observed. Further, decoding accuracy during learning should correlate with performance on the Orthographic Choice task. Given no comparable studies have manipulated the Syllable Length of experimental pseudowords, this effect will be observed without specific *a priori* predictions. In summary, this will be the first study of orthographic learning in adults that examines decoding under conditions that simulate an adult's natural learning environment (silently reading multisyllabic words). Overall, the results of this experiment will provide new insight into unanswered questions about adult orthographic learning.

2.0 METHOD

Participation in the study involved two sessions scheduled one week apart. The first session was a learning session where participants were exposed to a set of pronounceable pseudowords in the context of a story-reading task. The second session was a posttest session where participants completed two tests of orthographic learning for the previously read pseudowords: an orthographic choice test and a spelling test.

2.1 PARTICIPANTS

Eighteen undergraduate students enrolled in an introductory Psychology course at the University of Pittsburgh participated in this study for course credit (7 females; mean age = 18.82 years, *SD* = .81 years). All participants were native English speakers and provided informed consent for their participation.

2.2 MATERIALS

2.2.1 Experimental pseudowords

We developed a set of 12 pairs of pronounceable, monosyllabic homophonic pseudowords and 12 pairs of multisyllabic homophonic pseudowords. All of these pseudoword pairs differed in spelling, but they had the same target pronunciation (e.g., *meep* vs. *meap*). The monosyllabic pseudoword pairs were four to six letters in length and were selected from Kyte and Johnson (2006). The Kyte and Johnson study had a total of 16 pairs of pseudowords; however, we eliminated four of the 16 pairs for two reasons: 1) three of the four pseudoword pairs contained both consonant and vowel manipulations and we wanted to keep the difference between each homophonic pair to a single change, and 2) we wanted an even number of pairs so we eliminated one additional pair that had the same starting consonant as two other pairs.

The multisyllabic pseudowords were nine to 11 letters in length and were a subset of the 64 pseudowords tested by Chalmers and Burt (2008). Because the authors only provided one spelling for each of their pseudowords, we first created a homophone for each of the 64 items by manipulating either a consonant or a vowel so to form pairs with the same target pronunciation (e.g., *descimand* vs. *dessimand*). Then, we asked a set of 10 pilot participants to read all 128 pseudowords aloud. We eliminated any pseudoword pairs in which the items were pronounced differently by more than two pilot participants. This eliminated 51 pseudoword pairs, leaving us with 13 pairs. We then further eliminated the pseudoword pair most similar to a real word (*curtelage* and curtilage). The final set of 12 homophonic monosyllabic pseudoword pairs and 12 homophonic multisyllabic pseudoword pairs were randomly split into two lists, so that one spelling from each pair was assigned to List 1 and the other was assigned to List 2. The use of the two lists was counterbalanced across participants (see Appendix).

2.2.2 Experimental stories and comprehension questions

We fabricated 24 stories that were modeled after short stories used in a previous study of orthographic learning (Share, 1999). Each story was 133 – 157 words in length and used simple language. The stories were split into four sets of six stories. The order in which the four sets of stories were presented was randomly assigned but the same for every participant. One pseudoword from each pair (12 monosyllabic and 12 multisyllabic) was randomly assigned into each of these stories six times as a new vocabulary item (e.g., as a term describing a new color or new species). The embedded pseudoword from each homophone pair alternated across participants, so that half of the participants read stories with one spelling of the pseudoword pairs (i.e., List 1) and the other half read stories with the other spelling (i.e., List 2). The embedded pseudoword spellings constitute the Target items and the other spellings are the Homophone items. In addition to the experimental stories, two practice stories were created, in which the embedded items were two random monosyllabic pseudowords that are not part of the experiment. The stories were printed on single-sided pages, one story per page, in size 12 Times New Roman font and 2.0 line spacing. Finally, we designed two comprehension questions for each of the stories. These questions tested whether the participants paid sufficient attention to the stories they read to answer simple questions about their content.

2.2.3 Reading style survey

We developed a four-question reading survey to obtain feedback about the story reading experience. The survey was created as a pilot to examine the roles of inner speech and lip movements in silent decoding. The questions asked how often participants heard their own voice inside their heads when they read silently, how often they moved their mouth/lips during silent reading, and if the participants moved their mouths more during the first story or the second story. For these three questions, participants were given a fixed set of response options: never, almost never, sometimes/occasionally, almost always, or always. The final question was an open-ended response prompt about a participant's general reading style: During what times would you say you depend on mouth/lip movement during silent reading (e.g., extra concentration for a sentence, encountering a new word)? Because participants' answers were both fixed and open-ended, they were difficult to analyze and the results are not reported.

2.2.4 Orthographic choice task

The Orthographic Choice task was modeled after the Choice task used by Kyte and Johnson (2006) because it is a more comprehensive test of orthographic learning than the version used by de Jong and Share (2007) or Chalmers and Burt (2008). All 48 pseudowords in the experimental pseudoword set were included in the Orthographic Choice task. We also created an additional distractor pseudoword pair, called Foil 1 and Foil 2, for each existing pair in our pseudoword set. This was done by substituting the final consonant of each pseudoword pair with another consonant letter. Foils were also created for the practice pseudowords to orient participants to the Orthographic Choice task. As a result, on each trial of the Orthographic Choice task, participants selected from amongst a set of four choices: Target, Homophone, Foil 1, and Foil 2 (see Appendix). We used the Mail Merge Manager plugin for Microsoft Word to randomize the order in which the participants were exposed to the pseudowords. The plugin was used again to randomize the position of the four orthographic choices on each page. The four choices for each pseudoword were printed on single-sided pages with 2.0 line spacing. All choices were printed in lower-case letters with 18-point Times New Roman font.

2.2.5 Spelling task

To test the participants' recall for experimental pseudowords, we made recordings of the 24 target pronunciations of each pseudoword. The Mail Merge Manager plugin was used to generate randomized lists of the order in which to present the recordings. Answer sheets were created with numbered blank lines that are spaced with 3.0-line spacing. The lines were printed on single-sided pages with 12 lines to a page.

2.3 PROCEDURE

2.3.1 Learning session

Each participant was assigned to a quiet testing room and asked to read each story aloud or silently. First, to orient participants, the two practice stories with the embedded practice pseudowords were read (one aloud and one silent reading condition). For both the aloud and silent reading conditions, participants had to overtly indicate when they began to read a story by saying “begin” and when they were finished reading by saying “end.” The participants then answered two comprehension questions about each practice story. They were instructed to answer these questions to their best ability and to leave a question blank if they could not answer. After practice, participants were asked to read the four sets of experimental stories and answered comprehension questions after reading each of the experimental stories. One of the two reading conditions was randomly assigned to each set of stories across participants and they read two sets of the stories aloud and two sets silently. A desktop computer and the Adobe Audition software were used to record the reading of the stories. After providing the instructions, we did not provide further supervision of story reading and only periodically checked in on the participants' progress. After completing all reading materials, the participants were asked to take the reading style survey.

2.3.2 Posttest session

Seven days later, participants were tested in groups ranging from one to four individuals. The seven-day delay was modeled after the delay in children studies. It was implemented with the rationale that if a student is available at a particular time of day, they will also be available on the same day the following week. Testing was performed in a quiet conference room with sufficient spacing between each participant to avoid interactions during testing. Both the orthographic choice and spelling testing materials were distributed along with a pen. In the Orthographic Choice task, participants were prompted to circle the letter string that they were previously exposed to and to only make one final choice. The participants first completed practice trials with the two practice reading pseudowords. After being oriented, they continued through the remaining 24 experimental trials and were prompted to stop and wait for every participant to finish. No time constraint was put on the participants.

After the entire group completed the Orthographic Choice task, the participants were instructed to use the answer sheets for the Spelling task. The audio recording of each pseudoword pronunciation was played manually to the entire group via the Adobe Audition software with a speaker system. Participants were instructed to write down a spelling based on letter strings that they were previously exposed to. After hearing each item, they were given unlimited time to write down their answer on the answer sheet before they proceeded to the next item.

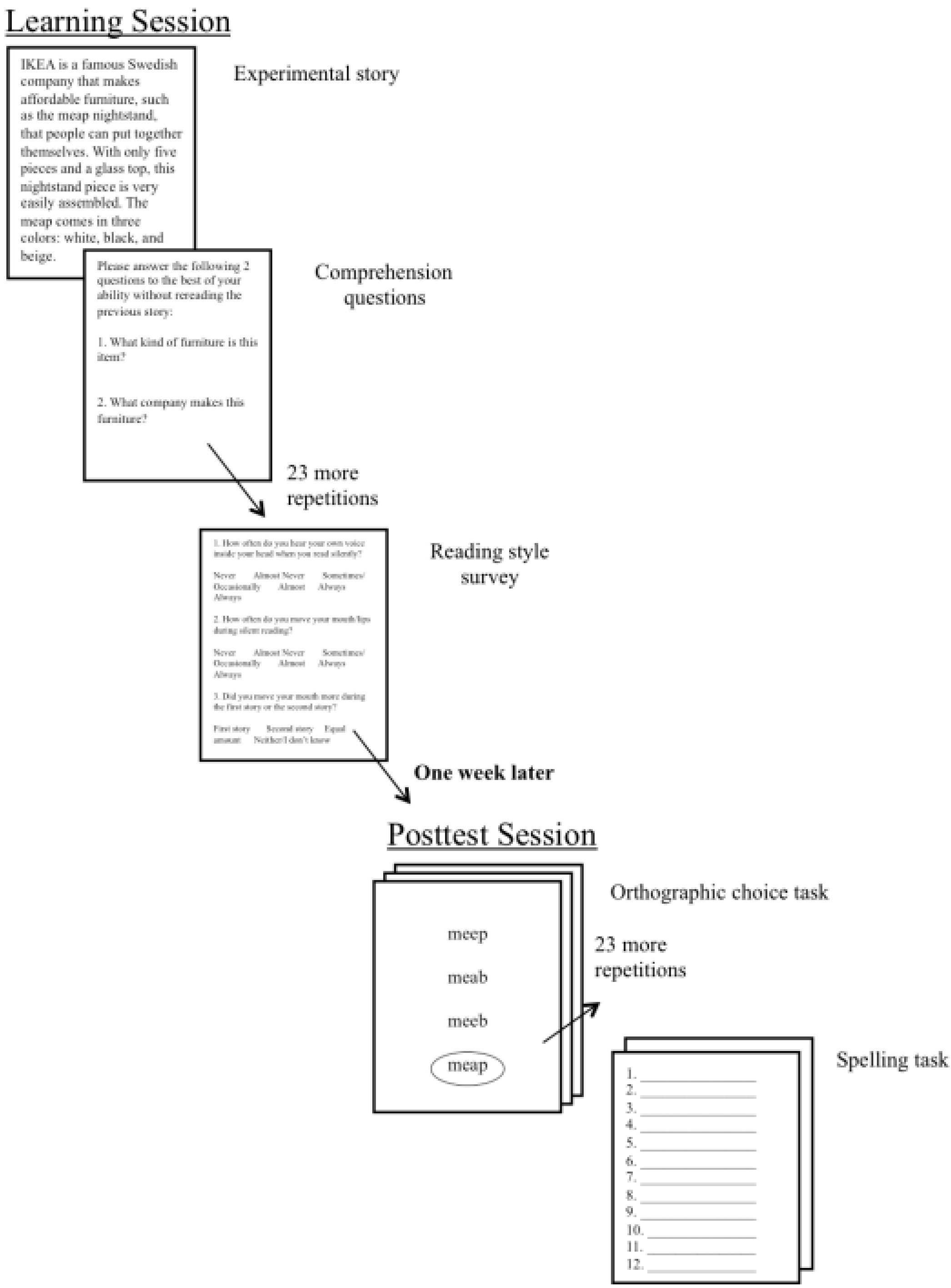

Figure 1. Experimental design with two testing sessions

3.0 RESULTS

3.1 LEARNING SESSION

3.1.1 Decoding accuracy

Participants were given a score of 1 for reading aloud a pseudoword correctly during all six exposures, a 0.5 for partially reading aloud a pseudoword correctly with mistake(s) during the six exposures, and a 0 for incorrectly reading aloud a pseudoword all six times. The correct pronunciation was determined by the pilot study and the linguistics researcher in the laboratory. Under the read aloud condition, participants successfully decoded target pseudowords with a mean accuracy of .85 (*SD* = .09). Since pseudowords were not overtly named during silent reading, the decoding accuracy for the silent reading condition cannot be reported (see Table 1). The audio files for four participants were lost and not included in computing the mean decoding accuracy.

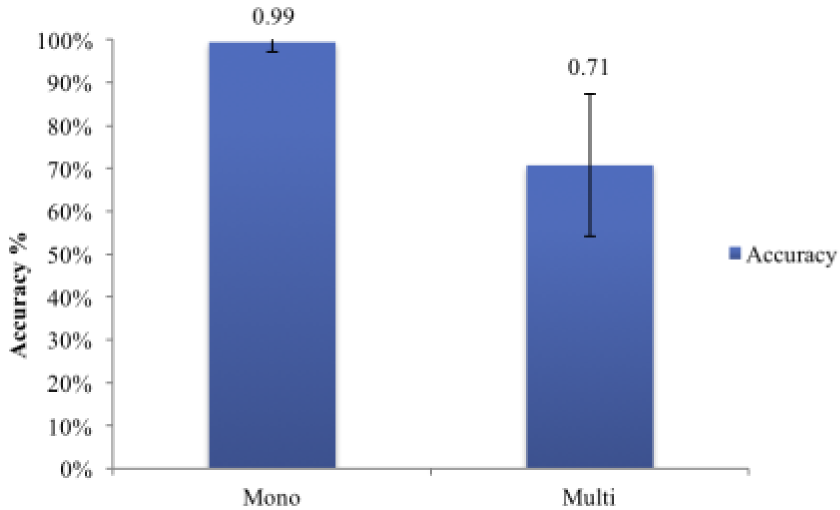

Figure 2. Decoding accuracy

3.1.2 Reading time

The reading time for each story was computed by subtracting the time immediately after a participant said “begin” from the time the participant said “end.” The mean performance values are provided in Table 1. A two-way analysis of variance (ANOVA) with repeated measures was performed on reading time where the independent variables were Reading Condition (read aloud or silent reading) and Syllable Length (monosyllabic or multisyllabic); the dependent variable was reading time. Two significant main effects were observed: 1) an effect of Reading Condition, $F(1, 17) = 63.93$, $p < .001$, with shorter reading time for silent reading over reading aloud and 2) an effect of Syllable Length, $F(1, 17) = 16.97$, $p = .001$, with shorter reading time for multisyllabic pseudowords. We did not observe an interaction between Reading Condition and Syllable Length.

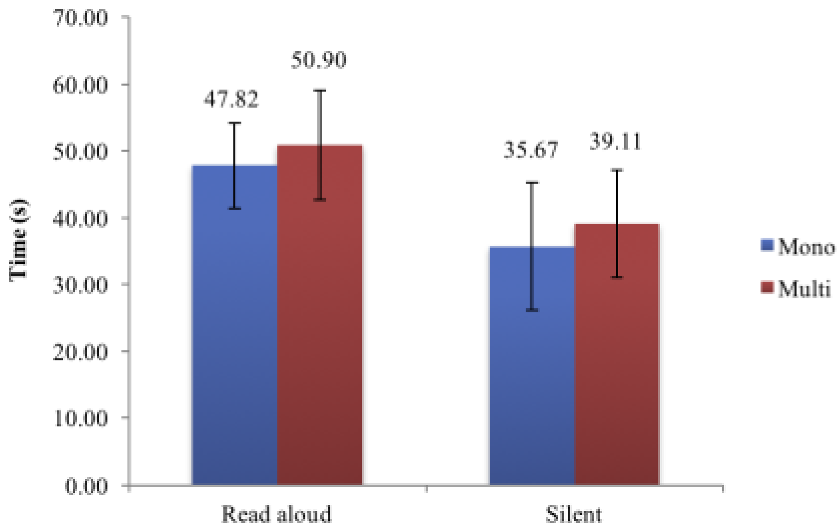

Figure 3. Reading time

3.1.3 Comprehension

The mean accuracy on the comprehension questions was .87 (*SD* = .08). Participants performed similarly on the comprehension questions under all four conditions (see Table 1). An ANOVA with repeated measures was performed on the mean proportion of correct responses on the comprehension questions. The independent variables were Reading Condition (read aloud or silent reading) and Syllable Length (monosyllabic or multisyllabic). No significant main effect was observed of either the Reading Condition or Syllable Length. Furthermore, there was no observed interaction between the two independent variables.

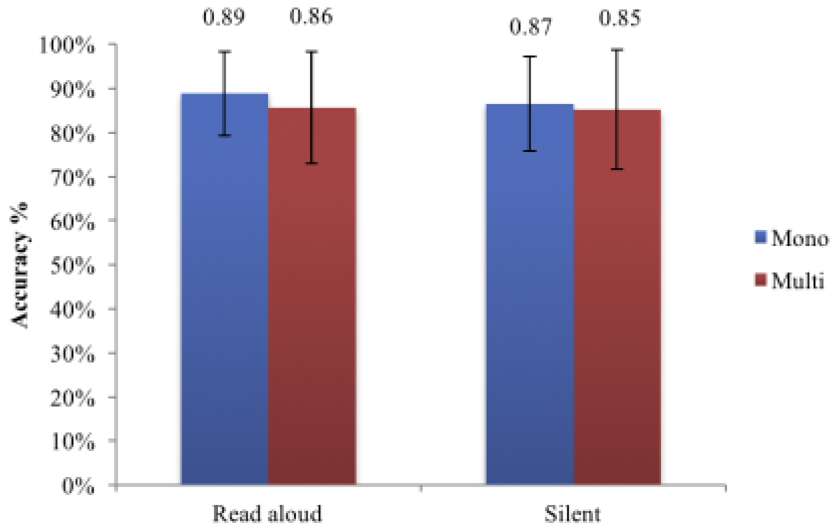

Figure 4. Comprehension accuracy

Table 1. Summary of results for the learning session

	Aloud		*Silent*	
Reading Measures	*Monosyllabic*	*Multisyllabic*	*Monosyllabic*	*Multisyllabic*
Decoding Accuracy	.99 (.02)	.71 (.17)		
Reading Time	47.82 (6.38)	50.90 (8.24)	35.67 (9.59)	39.11 (8.01)
Comprehension Accuracy	.89 (.09)	.86 (.13)	.87 (.11)	.85 (.14)

3.2 TESTING SESSION

3.2.1 Orthographic choice task

The first question of interest is whether adults demonstrate evidence of significant orthographic learning. This was tested using a strict measure of orthographic learning, namely the difference in Target versus Homophone selection (Cunningham et al., 2002; Share 1999, 2004). Using this measure, a paired-samples t-test provided evidence of significant learning, $t(17) = 2.58$, $p = .02$.

To explore differences in learning across our experimental factors, an ANOVA with repeated measures was performed with Reading Condition (aloud or silent) and Syllable Length (monosyllabic or multisyllabic) as within-subject factors, and the proportion of Target responses as a dependent measure. A significant effect was observed for Reading Condition, $F(1, 17) = 5.39$, $p = 0.03$, with participants selecting the target items learned under the read aloud condition ($M = .55$, $SD = .23$) more often than items learned under silent reading ($M = .43$, $SD = .12$). No main effect was observed of the Syllable Length variable and no significant Reading Condition x Syllable Length interaction was observed.

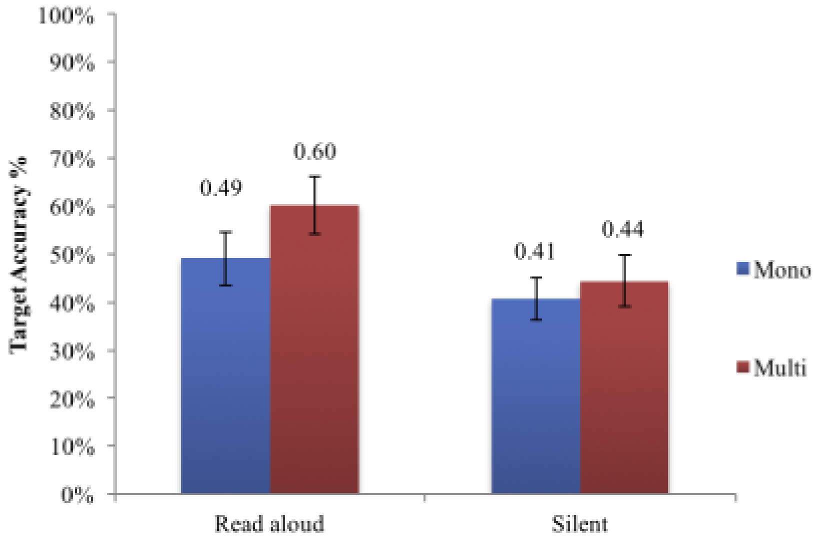

Figure 5. Orthographic Choice task accuracy

3.2.2 Spelling task

Since significant orthographic learning was detected by the Orthographic Choice task, we first investigate whether adults demonstrate also evidence of significant orthographic learning in the Spelling task. We again used the strict measure of orthographic learning, namely the difference between Target and Homophone spelling production. Using this measure, a paired-samples t-test similarly showed evidence of significant learning, $t(17) = 2.86$, $p = .011$. The paired-samples t-test was done with spelling accuracies that reflect the participants' ability to correctly reproduce the entire pseudoword items.

Modeling after de Jong and Share's Spelling task (2007), our Spelling task was scored in two ways: whole word and target letters. In whole word scoring, only pseudoword spellings that completely match the target spellings were graded as correct responses. The mean proportion of completely and correctly reproduced target items was .46 (*SD* = .15). An ANOVA with repeated measures was performed with Reading Condition (read aloud or silent reading) and Syllable

Length (monosyllabic or multisyllabic) as factors. No significant main effect was observed of the reading condition. However, a significant effect was observed in Syllable Length, $F(1, 17) = 6.58$, $p = .02$, where the target spelling of monosyllabic items were reproduced more often than target spellings of multisyllabic items. No interaction was observed between the two independent measures.

In target letters scoring, any spellings that included the targeted letters were scored as correct responses. The target letter was the one letter (with the exception of *stranoose* and *strannuce*) that differentiated the target and homophone spellings in each pseudoword pair. An ANOVA was performed with target letters scoring and no significant main effects were observed of either Reading Condition or Syllable Length. We also observed no significant Reading Condition x Syllable Length interaction was observed.

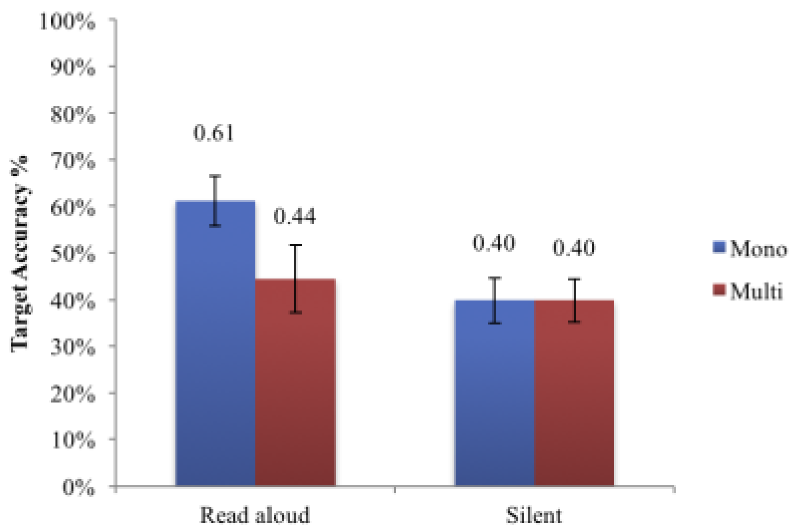

Figure 6. Spelling (whole word) task accuracy

Table 2. Summary of results for the posttest session

Task	*Aloud*		*Silent*	
	Monosyllabic	*Multisyllabic*	*Monosyllabic*	*Multisyllabic*
Orthographic Choice	.49 (.23)	.60 (.26)	.41 (.19)	.44 (.23)
Spelling (Whole word)	.61 (.23)	.40 (.31)	.44 (.21)	.40 (.20)
Spelling (Target letters)	.61 (.23)	.55 (.30)	.48 (.21)	.48 (.25)

3.3 RELATIONSHIP BETWEEN LEARING AND TESTING SESSION

We examined the relationship between the participants' target decoding accuracy and their level of orthographic learning, as measured by the Orthographic Choice task and the Spelling task. For the Orthographic Choice task and the Spelling task, only the accuracy scores for items decoded under the read aloud condition were included in the analysis. The data from the participants eliminated due to loss of audio recordings was also not included in the analysis. A linear regression was performed with target decoding accuracy as the independent variable and the target choice accuracy as the dependent variable. We observed a significant correlation between target decoding accuracy and the participants' ability to choose target items over the homophone and distractor items, $r(12) = .65$, $p = .01$. A similar linear regression was performed with the spelling accuracy as the dependent variable. We did not observe a significant correlation between decoding accuracy and whole word spelling or target letters spelling.

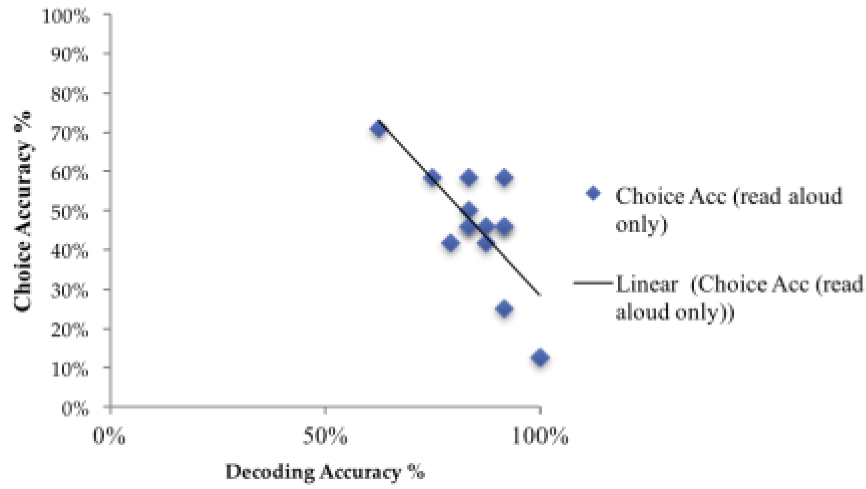

Figure 7. Correlation between decoding accuracy and Orthographic Choice accuracy

4.0 DISCUSSION

This study used an orthographic learning protocol to investigate Share's self-teaching hypothesis (1995) in adults. Share's theory predicts that both children and adults use phonological decoding to acquire orthographic knowledge about unfamiliar printed words, such as experimentally created pseudowords. While studies with children have provided substantial support for Share's theory, only a few studies have studied orthographic learning in adults (Burt & Blackwell, 2008; Chalmers & Burt, 2008). These studies offer inconclusive results about whether decoding occurs when adults read silently. It is also unknown whether they show a difference between learning simple words and learning orthographically complex words. Based on Share's theory, we predicted that adults should exhibit orthographic learning that is similar to that seen in children. Thus, the decoding ability of adults should correlate directly with their level of performance on the Orthographic Choice task. We also expected to find no significant difference between orthographic learning with pseudowords read aloud or silently. Given the ideas presented in the study by Chalmers & Burt (2008) about multisyllabic pseudowords and the results from the study by Burt and Blackwell (2008) with monosyllabic pseudowords, we observed the effects of Syllable Length without making predictions.

We found that adults show equivalent orthographic learning of monosyllabic and multisyllabic items as measured by the Orthographic Choice task but significantly better learning of monosyllabic items as measured by the Spelling task. More importantly, we found partial support for our predictions. In line with our predictions, we found that the decoding ability of adults does correlate directly with their orthographic choice accuracy. However, in contrast to prior results in children, we found significant differences in orthographic learning with silent versus aloud reading. Further, we observed that the significance varied across our two tasks of orthographic learning. Below, we consider explanations for these surprising results.

4.1 READING CONDITION

As mentioned, a significant main effect was observed of the Reading Condition such that participants performed better on the Orthographic Choice task with pseudowords decoded under the read aloud condition compared to the silent reading condition. However, when scoring for either whole word or target letters in the Spelling task, no main effect was observed of the Reading Condition. Below, we consider multiple explanations for the differing significance of Reading Condition on orthographic learning between adults and children.

First, adults might be showing the effects of the Reading Condition more strongly than children because of different aspects of our study design. Differences in statistical power due to differences in the sample size and variability in accuracy could affect how the results were interpreted. Our experiment has a smaller sample size than most studies of orthographic learning do. For comparison, de Jong and Share (2007) analyzed orthographic learning in 56 children whereas we tested 18 adults. Comparing our monosyllabic results with de Jong and Share's results, adults were less variable in choice under both reading conditions (Read aloud: SD = .31 versus SD = .23; silent: SD =.29 versus SD = .19). They were also less variable in spelling accuracies (Read aloud: SD = .32 versus SD = .23; silent: SD = .31 versus SD = .21). Given our smaller sample size and differences in variability, it seems unlikely that the differing results across studies are due to differences in power.

Second, the design of the Orthographic Choice task could have affected the outcomes. In de Jong and Share's experiments (2007), the Orthographic Choice task involved selecting from the target and its homophone, whereas in our experiment, the Orthographic Choice task involved selecting from the target, its homophone, and two foils. Including distractor foils in the Orthographic Choice task might have confused the adults and led to their worsened ability in choosing the target spelling. However, it is not clear how the difference in design could yield a stronger effect of Reading Condition.

Third, adults might be paying significantly less attention during the silent reading condition and therefore have not really learned the pseudowords silently. Consistent with this explanation, adults read significantly faster when they read silently than they did reading aloud. However, de Jong and collaborators (2007, 2009) showed that children also read significantly faster during silent reading but did not show a main effect of Reading Condition. Further, the comprehension results from adults show that adults have equivalent comprehension of both stories read aloud and read silently. Given these two points, it is unlikely that a simple lack of attention caused the difference in orthographic learning.

Finally, the stronger effects of Reading Condition in adults could be explained by changes in the mechanisms of decoding as beginning readers become skilled readers. This is consistent with Share's theory (1995) about decoding as a process that changes throughout reading development. In Share's theory, beginning decoding is reliant on letter-to-sound knowledge to break down unfamiliar words into segments. As reading skills develop, decoding becomes 'lexicalized' and the focus is shifted to visual patterns, or orthography. In other words, the learning process involves, more so than before, attending to orthographic details such as the consonant-vowel pattern (e.g., *meap* = CVC). Increased cognitive ability to memorize letter patterns, increased orthographic knowledge, and increased orthographic processing skills are all possible contributors to the lexicalized decoding process in skilled readers. Lexicalized decoding could explain why we observed significantly better performance with items learned under the read aloud condition. As readers transition into using a more lexicalized decoding, they can focus on processing visual patterns in addition to using letter-to-sound knowledge. In the read aloud condition, adults are forced to use beginner decoding to break down unfamiliar pseudowords into segments, which allowed them to decode as children do. However, they are able to use lexicalized decoding in addition to beginner decoding in the read aloud condition, whereas in the silent condition, adults might only be using lexicalized decoding. Our results demonstrated that orthographic learning does occur under the silent reading condition but reading aloud is still beneficial to adults when learning orthography.

Beyond tests of orthographic learning, adults also differ than children in comprehension skills. Because we did not focus our experiment on orthographic learning based on semantic information, we did not give major consideration to the effects of Reading Condition on comprehension. However, in the learning session, Reading Condition has been shown to affect comprehension in children. De Jong in his original work (2007) and in a follow-up study (2009) found that children comprehended stories that were read aloud significantly better than stories read silently. We did not find this pattern in our study of adult orthographic learning. This suggests that adults might have superior comprehension skills that allow them to equally access semantic information of texts read aloud or silently.

4.2 TESTS OF ORTHOGRAPHIC LEARNING

Although a main effect of Reading Condition was found in the Orthographic Choice task, no main effect of Reading Condition was observed in the Spelling task. Furthermore, a main effect of Syllable Length was found in the Spelling task but not the Orthographic Choice task. This finding raises questions about whether the tasks are equal measures of orthographic learning.

Consistent with this explanation, Chalmers and Burt (2008) demonstrated that performance on the Orthographic Choice task and Spelling task are predicted by different language abilities. In their third experiment, they reported that their Orthographic Choice task was predicted by performance on a phonological choice task and not general spelling ability. The phonological choice task was an ability test that measured the participants' ability to choose, from a pair of pseudowords, the item that sounded more like a real word (e.g., *warld* or *werld*). In contrast, their Spelling task was predicted by general spelling ability. Given that differing language abilities correlate with accuracies on the Orthographic Choice task and the Spelling task, we conclude that different skills are required to complete the two tests of orthographic learning.

Another piece of evidence that indicates the two tasks are not equivalent tests of orthographic learning is the correlation between decoding accuracy and posttest accuracy. Based on Share's self-teaching hypothesis (1995), we expected successful decoding to lead to skilled printed-word recognition. We report that decoding accuracy directly correlates with orthographic choice accuracy, which aligns with the self-teaching hypothesis. However, decoding accuracy did not correlate with Spelling task accuracy. This further suggests that the Orthographic Choice and Spelling tasks capture different aspects of orthographic learning.

The results from previous studies and our current experiment lead us to believe that the two tests do measure different aspects of orthographic learning. Speculatively, the Choice task might be a more sensitive measure of lexicalized decoding because the whole pseudoword forms were presented for choice. That is, because adults use lexicalized decoding, they may be processing words more holistically based on visual patterns in addition to breaking words down into individual letter-to-sound segments. This can explain why adults show a significant effect of Reading Condition in the Orthographic Choice task that was unobserved in children studies. In contrast, the Spelling task might be a more sensitive measure of letter-sound decoding. In order to spell a word, participants need to access knowledge of individual parts of the word to fully reproduce the word. However, no main effect of the Reading Condition was observed in the Spelling task in adults. This suggests that the use of beginner decoding with lexicalized decoding during the read aloud condition does not give adults an advantage to spell the learned items more correctly. Although we speculate that the two tests are measuring different aspects of orthographic learning, more research is required to investigate the nature of the two tests of orthographic learning.

4.3 FUTURE DIRECTIONS

Some limitations of the current study design should be addressed. Given that our small sample size could have affected the way the results were interpreted, future studies should attempt to replicate the study with a sample size comparable to the children studies. Future experiments could also focus on a better correlation study of inner speech and lip movement with orthographic learning to test how they contribute to silent decoding. A better reading style survey or other measures of inner speech and lip movement could contribute to determining whether silent decoding is essentially lexicalized decoding. This will allow for further insight into how decoding advances through development.

4.4 CONCLUSIONS

In closing, our findings offer the first typical study of orthographic learning in adults. We demonstrated that adult orthographic learning is correlated with their ability to decode, much like what de Jong and collaborators (2009) showed in children. However, we found evidence suggesting that adults do not use decoding the way children do. We expanded upon de Jong's work on the silent reading condition and unexpectedly found a main effect of the Reading Condition that suggests that adults might be using lexicalized decoding in addition to beginner decoding. We also tested the difference between decoding monosyllabic and multisyllabic items and found that adults decode monosyllabic items more accurately than multisyllabic items. Their superior spelling performance on monosyllabic items could be attributed to the amount of familiar words that are similar to the monosyllabic items, which make them easier to learn orthographically. Alternatively, the spelling performance could be attributed to merely the length of items. Despite seeming differences in our tests of orthographic learning and performance on these tests, the current study further confirms that orthographic learning occurs in adults through decoding and that decoding occurs under silent reading.

APPENDIX

EXPERIMENTAL PSEUDOWORDS

List 1

Target	Homophone	Foil1	Foil 2
blirm	blerm	blirf	blerf
broat	brote	broal	brole
drate	drait	drame	draim
feem	feam	feeg	feag
fleach	fleech	fleash	fleesh
hoat	hote	hoab	hobe
jeel	jeal	jeet	jeat
jope	joap	jole	joal
meap	meep	meab	meeb
sheal	sheel	sheag	sheeg
zait	zate	zair	zare
zoak	zoke	zoap	zope
descimand	dessimand	descimant	dessimant
glemitary	glemitery	glemitamy	glemitemy
leeresque	learesque	leereste	leareste
lurpurture	lirpurture	lurpurtube	lirpurtube
mavardion	mavardian	mavardiol	mavardial
misvearance	misveerence	misvearange	misveerenge
peckaroon	peccaroon	peckaroof	peccaroof
plaidance	plaidence	plaidanch	plaidench
reglessent	reglescent	reglessend	reglescend
ruktocian	ructocian	ruktociap	ructociap
stranoose	strannuce	stranoobe	strannube
wallorise	wallerise	wallorile	wallerile

List 2

Target	Homophone	Foil1	Foil 2
blerm	blirm	blerf	blirf
brote	broat	brole	broal
drait	drate	draim	drame
feam	feem	feag	feeg
fleech	fleach	fleesh	fleash
hote	hoat	hobe	hoab
jeal	jeel	jeat	jeet
joap	jope	joal	jole
meep	meap	meeb	meab
sheel	sheal	sheeg	sheag
zate	zait	zare	zair
zoke	zoak	zope	zoap
dessimand	descimand	dessimant	descimant
glemitery	glemitary	glemitemy	glemitamy
learesque	leeresque	leareste	leereste
lirpurture	lurpurture	lirpurtube	lurpurtube
mavardian	mavardion	mavardial	mavardiol
misveerence	misvearance	misveerenge	misvearange
peccaroon	peckaroon	peccaroof	peckaroof
plaidence	plaidance	plaidench	plaidanch
reglescent	reglessent	reglescend	reglessend
ructocian	ruktocian	ructociap	ruktociap
strannuce	stranoose	strannube	stranoobe
wallerise	wallorise	wallerile	wallorile

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