PHONEMIC AWARENESS AND READING ABILITY IN LITERATE ADULTS

by

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Susan B. Lorenson
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DEDICATION

To Dave, who never asked when it was going to be done.
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ABSTRACT

This dissertation is an examination phonemic awareness and its relationship to reading ability in literate adults. Phonemic awareness is an indisputable predictor of reading ability in children, but whether the same relationship between phonemic awareness and reading exists in adult readers is unknown. All alphabetically literate adults are understood to be phonemically aware to a certain degree. Moreover, adults pay attention to sound/symbol relationships when reading. Yet, the relationship between phonemic awareness and reading ability in alphabetically literate adults has not been explicitly studied, even though phonemic awareness is understood to be a key component of reading strategy and proficiency.

A study was conducted on phonemic and syllabic awareness in adults. The results indicate that adults, despite years of alphabetic reading experience, are differentiated with regard to phonemic awareness and are more syllabically aware than phonemically aware. Additionally, the study demonstrates that phonemic awareness is associated with reading ability in adults, though syllabic awareness is not. Implications and directions for future study are discussed.
1.0. INTRODUCTION

1.1 Overview

This dissertation is an examination of literate adults' phonemic awareness. Phonemic awareness refers not only to knowledge of letter/sound correspondences, but also to the ability to perform explicit manipulation tasks on units smaller than the syllable. Phonemic awareness has long been associated with reading ability in children (Adams, 1990; Stanovich, 1986; Ball & Blachman, 1991; Bradley & Bryant, 1983; Cunningham, 1990; Lundberg et. al., 1988). Myriad studies on children’s phonemic awareness in the last three decades have consistently shown that good readers possess a high level of phonemic awareness, whereas poor readers do not. As Mann puts it, "phoneme awareness bears both a logical and a proven relationship to early reading success. Its presence is a hallmark of good readers, its deficiency one of the more consistent characteristics of poor readers" (Mann, 1991, p. 260).

All alphabetically literate adults are understood to be phonemically aware to a certain degree. Moreover, these adults employ their knowledge of sound/symbol relationships when reading. Yet, the relationship between phonemic awareness and reading ability in alphabetically literate adults has not been explicitly studied. Despite the extensive research on and interest in phonemic awareness, experiments on the subject have been limited with regard to subject pool. Experiments aimed at understanding the connection between phonemic awareness and reading ability have been conducted primarily with children and special populations, such as illiterates (Morais et. al., 1986; Morais et. al., 1991; Koopmans, 1987), literates with non-alphabetic orthographies
(Read, 1986; Mann, 1986; Mann, 1991; Tzeng and Chang /in press/), dyslexics (Savin, 1972; Lecocq, 1986; Fox and Routh, 1983; Morais, 1983), and children with Down Syndrome (Cossu & Marshall, 1993). There is little, if any, research on literate adults, and yet, there is extensive evidence that adults (like children) pay attention to graphophonic detail when reading (Reicher, 1969; Wheeler, 1970; Van Orden, 1987; Lukatela & Turvey, 1994; Rayner, 2009; Ashby, 2005; O’Brien, 1988).

This dissertation reports the results of a study on phonemic awareness in adults, modeled on past phonemic awareness studies with children. The results of the study indicate that adults, like children, exhibit differing degrees of phonemic awareness, and that these levels of phonemic awareness are associated with reading ability. Additionally, the results provide evidence that even though the syllable (as opposed to the segment) plays a fundamental role in phonological processing, syllabic awareness bears no relation to reading ability. The implications of these findings, both practical and theoretical, are discussed.

1.2. Structure of the dissertation

The dissertation is divided into four chapters following this introduction. Chapters Two and Three review past research. In Chapter Two, phonemic awareness is defined, and an overview on previous research on phonemic awareness/reading research with children is presented. Chapter Three summarizes research related to the issue of phonemic awareness in adults, including phonemic awareness literature on special
populations and questions of the interaction of phonology and orthography when processing auditory and written signals.

Chapter Four presents the phonemic awareness study in detail. The study was designed to test the phonemic awareness skills of literate adults, and the relationship of those skills to reading ability. Six sub-tests of sound awareness were conducted in all. Performance on these sound awareness tests was analyzed with regard to performance on a test of reading ability and a test of analytical ability (a control measure).

The phonemic and syllabic awareness of participants was assessed by having them perform three sound awareness tasks (deletion, substitution, and permutation of phonological units) on two different phonological units (syllables and segments), resulting in six sub-tests of phonemic awareness in all (3x2=6). The table below illustrates this design:

\[
\begin{array}{|c|c|c|}
\hline
\textbf{Sound Awareness Tasks} & \textbf{Segment-based tasks} & \textbf{Syllable-based tasks} \\
\hline
\textbf{Deletion} & \text{Delete Segment Task (1)} & \text{Delete Syllable Task (2)} \\
\textbf{Substitution} & \text{Substitute Segment Task (3)} & \text{Substitute Syllable Task (4)} \\
\textbf{Permutation} & \text{Reverse Segment Task (5)} & \text{Reverse Syllable Task (6)} \\
\hline
\textbf{Test of Reading Comprehension} \\
\textbf{Test of Analytical Ability} \\
\hline
\end{array}
\]

As the table indicates, for each phonological manipulation (task) that participants were asked to perform, a pair of “sister” tasks was constructed: one in which syllables
were the unit of manipulation, and one in which segments were the unit of manipulation. This design allows for two distinct analyses of the data:

1. A comparison of participants’ performance on syllable-based tasks vs. segment-based tasks (in the context of task type), and
2. An analysis of the relationship between participants’ reading ability and their performance on the segment-based tasks vs. syllable-based tasks.

This two-part analysis explored several aspects of phonemic awareness in literate adults. The first part tested whether there are differing levels of phonemic and syllabic awareness in literate adults (that is, whether the participants process segments and syllables differently) and the second part tested whether there is a relationship between phonemic awareness and reading ability in adults, independent of analytical ability.

The predictions are as follows: First, because syllables are accessible phonological units to illiterates and preliterates, it is assumed (per Adams 1990 and many others) that syllabic awareness is a precursor to phonemic awareness, and that participants will perform better on syllable-based tasks than they will on segment-based tasks.

Second, it is expected, following the vast body of research on children’s phonemic awareness and reading ability along with evidence for graphophonic processing in adult reading, that participants’ performance on phonemic awareness tests will be a predictor of participants’ reading ability, independent of their analytical ability. However, since all literate adults exhibit some level of sound awareness, and since the
ability to manipulate syllables is present before the ability to manipulate phonemes and prior to reading experience (as demonstrated in preliterate children and illiterates), it is predicted that performance on segment-based tasks will be a significant predictor of reading ability, whereas performance on syllable-based tasks will not.

The final chapter is a conclusion, which ties together the results of the study with previous research on phonemic awareness, explores the syllable’s role in phonological processing, and touches upon the theoretical and pragmatic implications of the findings.
2.0 CHILDREN, PHONEMIC AWARENESS AND READING

In this chapter, phonemic awareness is defined, and some of the most salient issues in past phonemic awareness research are reviewed. Because the terms phonemic awareness, syllabic awareness and sound awareness will be used throughout this dissertation, we begin with definitions.

2.1. What is phonemic awareness?

Phonemic awareness is defined by Stanovich as “the ability to deal explicitly and segmentally with sound units smaller than the syllable” (Stanovich, 1993, p. 283). That is, phonemic awareness is both the knowledge that the word *cat* consists of three distinct phonemes (/kæt/) and not just one inseparable syllable, /kæt/, and the ability to isolate those phonemes on command (such as stripping the first phoneme off *cat* and producing /æt/).

The term "phonemic awareness" has quite a specific meaning in the field of reading education, referring to various levels of achievement on certain experimental tasks that are used as diagnostics of reading ability. For decades, the connection between phonemic awareness and reading ability has been poked, prodded and otherwise examined by researchers in the fields of Linguistics, Psychology, and Education. Over the last few decades, though, the term “phonemic awareness” has migrated from the jargon of Linguistics and Educational Psychology into the mass media, becoming a buzz phrase and a selling point for a number of products and services. Consider the excerpts below:
Literacy Resources, Inc. (LRI) is committed to instilling a love of all aspects of literacy and life-long learning! Our goal is to provide educators with resources and knowledge regarding the importance of a solid literacy curriculum, appropriately scaffolded for student achievement and success. LRI offers two versions of Dr. Michael Heggerty’s Phonemic Awareness curriculum and several Comprehensive Literacy in service sessions to help you meet your educational goals.

Researchers agree that **phonemic awareness** is the most important factor in learning how to read. Without these skills, students will be unable to catch up to their peers in reading ability or get a strong start….Sound Reading Solutions is the only reading software that triggers the three areas of the brain that guarantees reading success, first addressing phonemic awareness and fluency before the student works on phonics.

These interactive books enable prereaders to learn and practice **key phonemic awareness** skills and receive individualized audio support and feedback, preparing them to be successful readers. Each book includes phonemic awareness activities embedded in an engaging story that students will love.

2.2. **What is it not?**

In contrast, **syllabic awareness** refers to the ability to count and manipulate syllables on command; it is a less sophisticated level of linguistic awareness. **Sound awareness** (sometimes called phonological awareness or metalinguistic awareness) is an umbrella term encompassing both phonemic and syllabic awareness, and referring to any appreciation for the sounds of language.

2.2.1. **Implicit vs. explicit knowledge of phonemes**

When children learn to read, they must first break the alphabetic code (i.e., learn that letters correspond to sounds in a systematic fashion). This requires phonemes to move out of the normal, “subattentional” status which is characteristic of preliterate
development, makes the distinction between children’s *implicit* knowledge of
phonological units (as demonstrated by their speech perception and production) vs. their
*explicit* knowledge of those units. The term phonemic awareness refers to the latter, not
the former.

It is well established that even the youngest infants are able perceive differences
in speech sounds (Eimas et. al, 1971) and that, over the first year of life, infants develop a
language-specific (receptive) phonemic inventory (Werker & Lalonde, 1988). Preliterate
children perceive and produce minimal pairs, which differ by just one phoneme, and by
18 months, they are able to identify words mispronounced by one phoneme (Swingley &
Aslin, 2002). By 19 months, children exhibit “phonological constancy”; they are able to
ignore allophonic variation (phonetic variability) in the pronunciation of phonemes due to
dialect differences (Best et.al., 2009); by this age, phonemes have emerged as a
psychological construct.

Preliterate children also demonstrate sensitivity to phonemes in the production of
speech. Children routinely produce both developmental and spontaneous phoneme-based
errors. Developmental errors might include replacing a fricative with a stop (*tea for sea*),
a liquid with a glide (*wook for look*), or a palatal/velar with an alveolar (*sip for ship*).
Such substitutions often involve replacing one phoneme with another which shares a set
of phonetic features (Ingram, 1989). Spontaneous speech errors may or may not involve
feature similarity, as evidences examples of phoneme anticipation (*hoo hard for too*
hard) or phoneme metathesis (shkool soos for school shoes) (Stemberbger, 1989; Jaeger, 2005).

Each of the examples cited above provides evidence that children possess some knowledge of the phoneme. However, in all of these examples, the knowledge is subattentional, or implicit. Phonemic awareness, as referred to in this dissertation, is the explicit knowledge of phonemes. Adams notes that, in phonemic awareness research, “It is neither the ability to hear the difference between two phonemes nor the ability to distinctly produce them that is significant. What is important is the awareness that they exist as abstractable and manipulable components of the language” (Adams, 1990, p.65). A child may be able to perceive and produce phoneme differences, but may not be able to perform a simple phoneme awareness task, such as counting the number of “sounds” in cat.

2.3. What do we know about phonemic awareness and reading?

The remainder of this chapter is a review of research on phonemic awareness and reading. Four main findings will be explored in detail:

1. Phonemic awareness has an unequivocal association with reading ability in children,
2. Syllabic awareness (and rime awareness) are not associated with reading ability,
3. Phonemic awareness is not a developmental milestone in children, but rather requires alphabetic experience, and
4. The connection between phonemic awareness and reading is common across alphabetic orthographies
2.3.1. Phonemic awareness and reading ability in children

Liberman (1973) was the first to establish a connection between phonemic awareness and reading ability in children; 40 years later, it is still a thriving research topic. This section provides a brief historical overview of the seminal research on kids and phonemic awareness.

The vast majority of past research on phonemic awareness, conducted on newly literate or preliterate children, has centered on the following three interrelated claims:

1. **Children must be phonemically aware before they are able to read an alphabetic orthography.** (Adams, 1990; Ball & Blachman, 1993). The thrust of this claim is that before children are able to decipher a writing system which is based on sound-symbol correspondences, they must be able to break a word down into its individual sounds (phonemes), so that they are able to learn the relationship between these sounds and the letters (graphemes) to which they correspond.

2. **Phonemic awareness tasks can be used to predict a child’s later success or failure in reading.** (Adams, 1990; Mann, 1993; Bradley & Bryant, 1983, 1985; Fox and Routh, 1975, 1980; Stanovich, Cunningham & Cramer, 1984; Lundberg, Olofsson & Wall, 1980; Mann & Liberman, 1984, Brady & Shankweiler, 1991; Goswami & Bryant, 1990; Wagner & Torgesen, 1987). This claim posits that a child’s ability to manipulate (substitute, delete, etc.) the phonemes in a word predicts his/her future reading ability. A child who knows that “ice” is “nice” without the first sound will be a better reader than a child who does not understand this relationship. Furthermore, the connection between phonemic awareness and reading is independent of general intelligence or analytical skills (Stanovich, 1993).

3. **There are different levels of sound awareness.** (Adams, 1990; Trieman, 1983). Children progress in predictable stages through levels of sound awareness, with syllabic awareness preceding phonemic awareness.
2.3.1.1. Precursor to reading readiness

Ball & Blachman (1991) make a claim which is supported by many others, which is that children must be phonemically aware before they are able to successfully read an alphabetic orthography. Before a child can read, he/she must first understand that words are comprised of syllables and phonemes, and that in an alphabetic writing system phonemes correspond in a regular fashion to letters. Until that realization occurs, the written signal seems arbitrary; once it occurs, the written signal emerges as a logical system (Ball & Blachman, 1991).

This emerging realization is often referred to as “breaking the alphabetic code.” This decoding includes the application of grapheme-to-phoneme conversion rules (alternately called graphophonics rules or simply phonics rules), rules which tell the child that in the word cat, the grapheme “c” corresponds to /k/, the grapheme “a” to /æ/, etc.

Although reading involves the application of phonics rules and children must be phonemically aware to read, there is an distinction between phonemic awareness and mere phonics knowledge. The child who is phonemically aware possesses more than an extensive battery of “x stands for y” rules. Those [phonics] rules alone are useless unless the child is able to identify and manipulate the phonemes of a word. The child who has learned his or her phonics rules knows that “‘c’ stands for /k/, ‘a’ stands for /æ/, and ‘t’ stands for /t/.” The child who is phonemically aware knows that the isolated phonemes which these rules produce (/k/, /æ/, and /t/) yield a word in combination, /kæt/, which was once thought of as a single, impenetrable unit. The child who is phonemically aware is able to effectively use phonics rules to create and dismantle words.
As Ball & Blachman put it, “to read or spell phonetically regular words, a child must be aware that words can be broken into phonemes and that each phoneme corresponds to a symbol (or symbols) in our orthography” (Ball & Blachman, 1991, p. 63). Below is a simple illustration of the stages in a child’s phonemic awareness development:

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>/sʌn/</td>
<td>/sʌn/</td>
<td>/s...ʌ...n/</td>
<td>/s...ʌ...n/</td>
</tr>
<tr>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑↑↑</td>
</tr>
<tr>
<td>☺</td>
<td>☺</td>
<td>☺</td>
<td>S...U...N</td>
</tr>
<tr>
<td>SUN</td>
<td>S...U...N</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.1: Stages of Phonemic Awareness**

In stage (1) the child may recognize the aural stimulus /sʌn/ as referring to the big ball of light, and may recognize the printed word “SUN” as referring to the same object, but he or she has not necessarily made any direct (phonological) connection between the oral and written word. In stage (2), the child recognizes that /sʌn/ and SUN are connected, but is not able to abstract that knowledge - it is a fixed, limited piece of information. In stage (3), propose the child has developed phonemic awareness, and can perceive the word *sun* as consisting of three distinct phonemes (and, similarly, has learned the alphabet and sees “SUN” as three distinct letters). Finally, in stage (4), the child has learned the connection between the distinct phonemes of /sʌn/ and the distinct graphemes of “SUN.” This knowledge is abstractable, because it can be applied to other correspondences of /s/ and “S,” for instance.

This simplified schema demonstrates how reading is the application of appropriate grapheme-to-phoneme conversion rules (the "alphabetic code"), which require that the child is able to identify and manipulate the phonemes in a word.

**Phonemic Awareness and the “reading wars”**
Not all reading specialists agree that phoneme-grapheme rules (which comprise the alphabetic code) need to be taught to emerging readings, nor do they agree that phonics knowledge is a prerequisite for reading. Whole language advocates view things differently. Goodman (1993) argues that alphabetic coding is unnatural, that English spelling is riddled with exceptions which violate phonics rules, and that children should be taught to read words as whole units. If a child encounters an unfamiliar word when reading, he/she is encouraged to use context (semantic) clues to decipher its meaning.

Whole language advocates do not argue that phonemic awareness is a characteristic of skilled readers, but they simply propose that children figure it out for themselves once they start reading. The phonics teacher tells Johnny that *cat* begins with /k/ and that is spelled with a “c,” and imagines that this will help the child figure out that words can be broken down into phonemes. The whole language teacher gives Johnny a book with many *cat/hat* rhymes, until he figures out for himself that the sound and letter similarity between the words isn’t mere coincidence (and that the /k/-/h/ difference corresponds to the “c”/”h” difference). Either way, the child eventually learns that *cat* can be broken down into three distinct units, and this is the beginning of explicit phonemic awareness.

Since phonemic awareness is more strongly associated with reading skill than mere phonics knowledge, some have suggested that phonemic awareness should be taught, instead of (or in addition to) teaching phonics rules (Bradley and Bryant, 1983; Tornéus, 1984; Ball & Blachman, 1991; Hatcher, Hulme, & Ellis, 1994). Phonemic awareness training is emerging as a way to bridge the gap between the often disparate
approaches to reading of phonics instruction and whole language instruction, in which readers are encouraged to read without relying on explicitly taught rules.

Consider the table below, which illustrates the various qualities of traditional phonics instruction, 70s-era “whole language” instruction, and phonemic awareness training:

<table>
<thead>
<tr>
<th></th>
<th>Phonics Instruction</th>
<th>Phonemic Awareness Training</th>
<th>Whole Language Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphophonic rules taught explicitly e.g., ‘c’ stands for /k/</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graphophonic rules learned without explicit instruction e.g., students are given texts with juxtaposed rhyming words like “cat” and “hat” and eventually figure out that the ‘c’/’h’ difference corresponds to the /k//h/ difference</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Explicit training in identifying the components of a word (phonemes) e.g., students are taught to “sound out” and “break down” words</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.2: Approaches to Reading Instruction**

Educators in the phonics camp believe that the road to reading is paved with explicit instruction in sound/symbol correspondence rules (grapheme x stands for phoneme y). Phonics teachers worry that the whole language approach, with its lack of explicit instruction, leaves many children behind. They argue that whole language instruction may succeed for normal children with high levels of print exposure from an early age (those who have already learned to make some connections between the spoken and printed word), but that it will fail children who do have not have this background or who have another obstacle (e.g., dyslexia) to making sound/symbol connections on their own. The belief is that children will best learn to read when they are given the proper
tools, that is, the set of rules which draws connections between the 26 letters of the alphabet and the phonemes of English.

Whole language adherents believe that instruction in phonics is confusing, because there are so many exceptions to the explicitly taught rules (one can’t help thinking of the George Bernard Shaw observation that fish could be spelled ghoti, with the gh from laugh, the o from women, and the ti from caption). They believe that children, given enough time and exposure to language, will figure out the rules on their own in a natural way. They encourage exposure to rhyming books like Dr. Seuss’ The Cat in the Hat, in which minimal pairs are repeatedly juxtaposed, and imagine that this will foster the development of “personal phonics rules” in children (Goodman, p. 108). This method of learning, they argue, allows for the learning of more complicated words, those which violate rules of phonics. So, when a reader sees the words face and fake juxtaposed, he or she will use context to figure out the difference between the two words, and will subsequently create a rule to account for the difference (k always stands for /k/, but c only sometimes does). In theory, the phonics student would either have to learn a sophisticated rule to tackle face (c stands for /s/ between two vowels), or would be completely thrown off by the c=/k/ rule.

Phonemic awareness training shares features with both phonics and whole language approaches: it is a method of explicit, linguistic instruction, and yet it is not based on the teaching of inconsistent phonics rules. In phonemic awareness training, children are taught to play games that foster their phonemic awareness skills. For example, a child might be given a block for every phoneme in a word (e.g., three blocks
for *wake*, four blocks for *cart*). When the first block in a linear series is removed, the child would be expected to pronounce the remaining word without the first phoneme (*ache* or *art*), if the last block is removed, without the final phoneme (*way* or *car*). Note that the manipulations in this exercise do not rely upon graphophonic rules, and in fact may “violate” them (*wake* has four graphemes but three phonemes). Because phonemic awareness training is not dependent upon phonics rules, training exercises may also be performed with preliterate children who have not yet been exposed to phonics rules.

Thus, phonemic awareness training, phonics teaching and whole language instruction are all quite different approaches to the teaching of reading; a National Reading Panel meta-analysis of 52 independent studies over the last 30 years concluded that phonemic awareness training has a consistent, statistically significant effect on word reading and comprehension in emerging readers (Ehri, et. al., 2001).

### 2.3.1.2. Connection with reading

The strongest and most studied claim about phonemic awareness is that it is both a predictor and a correlate of a child’s success in reading (Adams, 1991). Mann (1993) argues that either the presence or absence of strong phonemic awareness skills is significant: she calls phonemic awareness a “hallmark” of good readers and notes that deficient phonemic awareness is consistently associated with poor readers. Moreover, the connections between phonemic awareness and reading are independent of general intelligence or other metalinguistic skills (Stanovich, 1993). Some more detail on the structure of these studies is discussed below.
Children who demonstrate the highest levels of phonemic awareness on the basis of phonemic awareness tasks turn out to be the best readers (Bradley & Bryant, 1983, 1985; Fox and Routh, 1975, 1980; Stanovich, Cunningham & Cramer, 1984; Lundberg, Olofsson & Wall, 1980; Mann & Liberman, 1984, among others). In each of these studies, children were tested on a variety of phonemic awareness tasks, including, but not limited to, the following:

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Sample instructions</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoneme blending</td>
<td>Put /m/.../a/.../p/ together and what do you get?</td>
<td>/maep/</td>
</tr>
<tr>
<td>Phoneme segmentation</td>
<td>What sounds do you hear in the word hot?</td>
<td>/h/.../a/.../t/</td>
</tr>
<tr>
<td>Phoneme counting</td>
<td>Tap out the sounds in map.</td>
<td>3 taps</td>
</tr>
<tr>
<td>Phoneme matching</td>
<td>Do pipe and pen begin with the same letter?</td>
<td>yes</td>
</tr>
<tr>
<td>Deleted phoneme</td>
<td>What sound do you hear in meat that is missing in eat?</td>
<td>/m/</td>
</tr>
<tr>
<td>Phoneme oddity</td>
<td>Which of these doesn’t belong? pig, hill, pin</td>
<td>hill</td>
</tr>
<tr>
<td>Phoneme deletion</td>
<td>What would is left if you take off the first sound in nice?</td>
<td>/ays/</td>
</tr>
<tr>
<td>Phoneme substitution</td>
<td>What would feel sound like if it started with /m/?</td>
<td>/mil/</td>
</tr>
</tbody>
</table>

**Figure 2.2: Phonemic Awareness Tasks**

These task descriptions are all drawn from Adams (1990) and Stanovich (1983).

In these studies, children’s performance on phonemic awareness tasks was compared with their performance on (1) other sound awareness tasks, (2) other cognitive tests, and (3) reading and spelling tests. The other sound awareness tasks test less sophisticated levels of children’s phonological abilities, such as syllabic awareness (i.e., syllable counting, in which children are asked to tap out the syllables in a word), or even poem awareness (i.e., the ability to recite nursery rhymes). The (non-linguistic)
cognitive tests are usually IQ tests, and the reading tests are standard school measures of reading ability, such as the Peabody Picture Vocabulary Test (Dunn & Dunn, 2007) with very young participants (Ball & Blachman, 1991; Bowey & Francis, 1991) and the Metropolitan Reading Readiness Test (Nurss & McGauvran, 1988) with older children (as seen in Stanovich, Cunningham & Cramer, 1984; Cunningham, 1990; Hatcher et. al., 1994; Mann, 1993). Each of these classic phonemic awareness studies reached the same conclusion: preliterate children who perform best on phonemic awareness tests turn out to be the best readers, regardless of IQ or other cognitive skill (Stanovich, 1983).

These connections between phonemic awareness and reading are well-established and uncontroversial, as noted by several large-scale meta-analyses in the last decade. A report prepared by the National Reading Panel for Congress in 2002 summarized and analyzed 52 independent studies on phonemic awareness and reading ability in children, all of which appeared in peer-reviewed journals. The report determined, consistent with the studies cited in this section, that phonemic awareness has a consistent, statistically significant relationship to reading ability in children (Anthony & Francis, 2005). Castles et. al. (2009) meta-analyzed over 40 longitudinal studies of phonemic awareness and concluded that all showed a significant and unique contribution of phonemic awareness to reading ability.

2.3.1.3. Levels of sound awareness

Implicit in phonemic awareness research is the notion that children pass through predictable, increasingly sophisticated stages in their development of phonemic
awareness. It would be inaccurate to refer to these as developmental milestones, as phonemic awareness skills may not develop without exposure to an alphabet (see section 2.3.3). However, when children do develop phonemic awareness, they do so in a logical fashion.

Adams (1990) identifies five levels of phonemic awareness that can be used to classify the experimental tasks that have been used in past experiments with children. The levels are listed below in increasing order of sophistication; mastery of the highest levels of phonemic awareness is most likely to be connected to reading ability.

Each level is listed with an example of an experimental task that might be used to assess it:

1. Appreciation for the sounds of words

Ex. **Nursery rhymes**: children (ranging in age from 3 months to 4 years) were tested on their knowledge of and ability to recite five popular nursery rhymes (Adams, 1990)

2. Phonemic identification/grouping skills

Ex. **Oddity tasks**, in which children are given a list of words with a phonemic contrast in the beginning, middle or end of the word (e.g. pig, hill, pin) and asked "Which of these doesn't belong?"

3. Phonemic isolation skills

Ex. **Blending tasks**, in which the experimenter gives the child segments in isolation ("/m/.../a/.../p/") and the child is asked to put them together ("map"), and **syllable splitting tasks**, in which children are asked to split the rime of a syllable from its onset (producing "eel" and "ice" when the experimenter says "feel" and "mice").

4. Phonemic segmentation skills
Ex. **Phonemic counting tasks**, in which children were given a word and asked to "tap out" how many sounds (phonemes) it contained (so, "map" should get three taps).

5. Phonemic manipulation skills

Ex. **Phoneme manipulation tasks**, in which children are asked to leave out an initial, medial, or final phoneme in the pronunciation of a word (e.g. "Say 'hill' without the /h/"; "Say 'monkey' without the /k/," etc.).

Read (1986), Treiman (1993) and Adams (1990) also note that children’s emerging phonemic awareness is reflected in their spelling abilities, particularly their “invented” spelling (spelling errors). Treiman identifies five levels of phonemic awareness revealed by children’s spelling errors:

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precommunicative</td>
<td>(no phonetic or phonological structure)</td>
</tr>
<tr>
<td></td>
<td>↓</td>
</tr>
<tr>
<td>Semiphonetic</td>
<td>(idea that letter=segment; ex. CRPT for &quot;carpet&quot;)</td>
</tr>
<tr>
<td></td>
<td>↓</td>
</tr>
<tr>
<td>Phonetic</td>
<td>(no omissions)</td>
</tr>
<tr>
<td></td>
<td>↓</td>
</tr>
<tr>
<td>Traditional</td>
<td>(mistakes reflect learned correspondences; ex. EIGHTEE for &quot;eighty&quot;)</td>
</tr>
<tr>
<td></td>
<td>↓</td>
</tr>
<tr>
<td>Correct</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.3: Levels of Sound Awareness Revealed in Spelling**

Learning to spell may be considered a form of phonemic awareness training for children; children’s attempts at spelling scaffold their emerging phonemic awareness (Adams,
Mann (1993) found a correlation between the sophistication of children’s invented spellings and their reading ability. This correlation could be because the best invented spellers have, in a sense, received a dose of phonemic awareness training.

Absent from both the Mann and Trieman models is a place for syllabic awareness (though Trieman’s “semiphonetic” stage might be called onset/rime awareness). Clearly, syllabic awareness in either model would fall between the two lowest levels. Liberman et. al. (1974) was among the first to demonstrate that preliterate preschoolers are able to segment syllables (in a counting task) long before they are able to conduct the same task on segments. In a large-scale study of nearly 1000 emerging readers, all aged 2-5, Anthony et. al. (2003) confirmed the previous research findings by Mann and others, showing specifically that young children gain sensitivity to linguistic units in a predictable, developmental fashion. Testing children on four linguistic units (word, syllable, onset or rime and phoneme) and four levels of manipulation (blending detection, elision detection, blending and elision), the researchers demonstrated that children are able to detect phonological units (specifically, phonemes) before they are able to manipulate them in phonemic awareness tasks. The units were as large as words (cow...boy) and as discrete as phonemes (/f/.../v/.../f/), and participants were asked to either detect the response (i.e., What do you get when you say ‘farm’ without the /f/? Pick the picture which answers the question) or produce the response (i.e., Say ‘Mike’ without /k/). Ultimately, the researchers describe sound awareness as developmental and hierarchical, moving through the predictable stages of word awareness to syllabic awareness to onset/rime awareness to phonemic awareness (for similar finding, see also
Mann, 1990; Anthony, Lonigan, Driscoll, Phillips & Burgess, 2003; Ziegler & Goswami, 2005; Ziegler & Goswami, 2006).

Research also suggests that, even once children are phonemically aware, their phonemic awareness skills continue to develop. For instance, “synthetic” phonemic awareness skills, like blending, appear to develop before “analytic” phonemic awareness skills, like segment deletion (Anthony et al., 2003; Lonigan et al., 2009).

2.3.1.4. Causality

The view of phonemic awareness as a predictor of future reading ability has been criticized on the grounds that it may be tapping into past reading experience, rather than future reading ability. The causality question has been argued both ways (Ziegler and Goswami, 2005; Hulme et al., 2005). Perhaps children who score well on phonemic awareness tests are those who have watched Sesame Street, been read to by their parents, been encouraged to write at home, etc. (Lundberg et al., 1988). Then, children who fail to perform well on phonemic awareness tests may have simply missed out on print exposure and pre-reading literacy experiences.

Longitudinal studies on the effect of phonemic awareness training favor the view that phonemic awareness skills lead to reading improvements. A 2008 National Institute for Literacy meta-analysis of 52 independent studies claimed to find a consistent, statistically significant effect of phonemic awareness training on later word reading and comprehension in emerging readers (Ehri, et. al., 2001). However, reviews explicitly focused on the causality question (Castles et. al. 2009; Castles & Coltheart, 2004) claim
that there is no unequivocal evidence of a causal link. In order to establish such a link, the authors claim, phonemic awareness training studies would need to (1) control for past reading experience by testing children with zero prior reading skills, and (2) modify phonemic awareness training protocols to ensure that they only include training on phonemes and not other speech units (onsets, rimes, syllables). Both of these suggestions present challenges.

With regard to prior reading experience, it is well established that most American children have had hours of indirect reading instruction via media, educational toys, etc. before entering school (Adams, 1990). Secondary language activities, such as rhyming songs and language play, may explain why Lundberg (1991) found that 9 out of 51 prereaders exhibited perfect performance on a segmentation task, even though the children had participated in similar language activities in and outside the school. Children’s invented spellings in the pre-reading stage provide evidence of this exposure (Treiman, 1993). However, there can be great variation in the quality and quantity of early reading exposure (Lonigan et al., 2013). A study by Mann and Wimmer (2002), demonstrates that variability can also be cultural; they compared the phonemic awareness skills of American kindergartners, who are taught letters and sounds prior to schooling, with those of German kindergartners, who are not. The American children excelled on phonemic awareness tasks compared to their German counterparts. Without controlling for prior print exposure, the theory might predict that the American children would become better readers.
Controlling for phonological units in phonemic awareness training may be an easier task. Hulme et. al. (2012) took on this challenge; they trained children on lettersound knowledge and phonemic awareness alone, and found that 5 months after the training concluded, word-level reading skills in children had significantly improved.

It is likely that future studies will continue to control for issues that may cause causality into question.

2.3.2. Syllabic and rime Awareness

Because preliterate children evidence syllabic awareness and rime awareness prior to phonemic awareness (Liberman et al., 1974; Treiman & Baron, 1981; McBride-Chang & Ho, 2005), it can be difficult to separate out the unique contributions of different types of sound awareness to reading. Some early phonemic awareness studies were criticized on the grounds that since children who are phonemically aware are necessarily syllabically aware, any relationship with reading skills might be testing overall sound awareness vs. phonemic awareness alone. A few studies have even posited that syllabic awareness is a predictor of reading ability (Liberman et al. 1974; Treiman and Danis 1988; Treiman et al. 2002). However, recent research suggests that only phonemic awareness is a true predictor of reading ability in children.

2.3.2.1. Syllabic awareness

In a longitudinal study, Badian (1998) tested syllabic segmentation skills in 238 preschoolers. When the children’s reading ability was tested in first and second grade, syllabic awareness was determined to have made no unique contribution to reading
ability, controlling for other factors (such as phonemic awareness and intelligence). Similarly, Elbro et al. (1998), studying Danish preschoolers, found that neither syllable deletion nor syllable identification skills contributed to reading skill. Castles et. al. (2009) examined over 40 longitudinal studies of the relationship between phonological awareness and reading published since the late 1970s and found no evidence in any study for a unique contribution of syllabic awareness to reading ability.

2.3.2.2. Rime awareness

As with syllabic awareness, some early studies identified rime awareness as a predictor of reading ability (Goswami, 1993, 1999; Goswami & Bryant, 1998). These studies have been criticized on the grounds that rhyming (and rime awareness) is an early developmental stage in children’s sound awareness but not a longer-term measure of reading success (Anthony et al., 2003). Hulme et. al. (2002) tested 5-to-6 year olds on their ability to delete, detect and identify phonemes and sub-syllabic units (onsets and rimes). Though phonemic awareness was (as expected) both a concurrent correlate and a later predictor of reading skill, onset and rime awareness was neither (see also Muter et al., 1998).

Meta-analyses by Macmillan (2002) and Castles & Coltheart (2004) of studies on phonemic vs. syllabic vs. rime awareness in children conclude that of the three, only phonemic awareness is associated with reading ability (also, Caravolas, Voln & Hulme, 2005; Ehri et al., 2001). A meta-analysis of research on dyslexics found that, in 235 studies on phonemic awareness, rime awareness and short-term memory, phonemic
awareness was the only strong and consistent predictor of reading ability (Melby-Lervåg, Lyster & Hulme, 2012).

In short, there is no compelling evidence that syllabic awareness or rime awareness is a unique predictor of reading ability in children; only phonemic awareness can lay claim to that title.

2.3.3. Phonemic Awareness is not a developmental milestone

Earlier, we noted that children pass through predictable stages in their development of phonemic awareness. In this section, evidence is presented that, although phonemic awareness develops predictably in alphabetic readers, it is not a developmental milestone. Rather, phonemic awareness seems to require an external (alphabetic) trigger in order to develop. This section highlights work on phonemic awareness in illiterates and literates of nonalphabetic orthographies.

2.3.3.1. Phonemic awareness in illiterates

Studies on sound awareness in illiterates suggest that they don’t develop phonemic awareness comparable to literates in the absence of alphabetic exposure, but do develop comparable sound awareness of other units (syllabic, rime). This bolsters the claim that there is a unique connection between phonemic awareness and reading skill.

Morais et. al. (1986, 1991) studied Portuguese illiterates and ex-illiterates (who learned to read and write as adults). The study compared the two groups with respect to their performance on a phoneme manipulation task, a syllable manipulation task, and a melody segmentation task (in which participants had to play the last three notes of a four-note melody on a xylophone). The only significant difference was in the phonemic
segmentation abilities of the illiterates (who could not do segmentation tasks) and the ex-illiterates (who could do segmentation tasks). Morais appeals to the idea of "levels" of sound awareness: while onset-rime awareness and syllabic awareness might develop without exposure to an alphabetic orthography (since illiterates can perform tasks involving those units), phonemic awareness requires alphabetic experience. So, phonemic awareness is not an inevitable maturational development, but rather a fallout from reading.

Others have replicated and built upon Morais’ work. Lukatela et. al. (1995) found that illiterate Serbo-Croations differed from their literate counterparts on measures of phonemic awareness (phoneme deletion and phoneme counting) but not other measures of sound awareness (syllable counting and tone counting). Loureiro et. al. (2004) studied phonemic awareness, rime awareness and reading ability in Brazilian illiterates and semi-literate. There was a relationship between phonemic awareness and reading ability but no such relationship between the ability to identify rhymes and reading ability. Matute et. al. (2012) tested 6-13 year-old Mexican illiterates, matched age-wise with literates. Though the illiterates demonstrated similar implicit knowledge of phonemes (as demonstrated by their ability to discriminate minimal pairs), they did not perform well on measure of explicit phonemic awareness (i.e. phoneme counting and blending). Finally, Landgraf et al. (2012) studied phonemic awareness training in illiterates. After one year of training, they improved in phonemic but not syllabic awareness, indicating that the former skill responds to environmental experience whereas the latter is
developmental. And yet, despite improvement, the illiterates were still unable to achieve literates’ phonemic awareness levels.

An emerging area of research examines the effect of literacy (and alphabetic literacy in particular) on the brain. There is evidence for unique neural activation based on type of literacy [logographic vs. alphabetic] (Bialystok & Luk, 2007; Perfetti et. al., 2007) and age of literacy [never vs. adult-onset vs. child-onset] (Dehaene, et. al., 2010).

2.3.3.2. Phonemic awareness in literates with nonalphabetic orthographies

Research on readers of non-alphabetic orthographies provides additional evidence that phonemic awareness requires alphabetic experience and will not develop in its absence.

Read et. al (1986) compared the performance of two groups of Chinese adults. The first group knew only the traditional logographic (character) writing system, whereas the second was also familiar with pinyin (alphabetic transcription). Only the second group of subjects, who had received explicit training in an alphabetic system, performed well on phoneme awareness tasks. Mann (1986) compared the performance of American first graders and Japanese first graders on syllable and phoneme manipulation tasks. Though both groups of children performed well on the syllable manipulation task, only the American children, who had already been exposed to an alphabetic writing system, performed well on a phoneme manipulation task. Japanese children, who knew only a syllabary, performed poorly on these tasks. Additionally, Ben-Dror et. al. (1995) found that English readers outperformed Hebrew counterparts in a phoneme deletion task. All
of these studies suggest that it is not just literacy, but alphabetic literacy, which is associated with phonemic awareness.

Yet, Mann also found that Japanese fourth graders, despite lacking an alphabet, performed well on phonemic awareness tasks (Japanese sixth graders, having learned romanji, or the roman alphabet, perform well on these tasks, too, as expected). In some Chinese literatures, phonemic awareness is associated with reading ability (Tzeng, 1994). Since these groups have had no alphabetic training, why were they groups able to perform well on phonemic awareness tasks?

The answer may lie in indirect alphabetic instruction. Morais suggests that the phonemic awareness abilities of Japanese fourth graders who had no exposure to an alphabet can be understood by taking into account the way kana is taught. Japanese children learn kana by means of a matrix in which all the characters in a row share the same vowel and all the characters in a column share the same consonant, except the first column to the right that consist of isolated vowels. It is possible to obtain a good performance in the deletion task by referring to the matrix (Morais, 1991, p. 17).

Similarly, Tzeng (1994) notes that more than 85% of Chinese characters are phonograms, consisting of a radical (which signals semantic category), and a phonetic component (which signals pronunciation). Thus, as readers learn characters, they must engage in phonetic segmentation.

The takeaway is that phonemic awareness instruction does not have to be as explicit as learning an alphabetic writing system. If some aspect of language pedagogy includes attention to the initial segments of a word, it may serve as a de facto form of
alphabetic instruction. This could also explain why phonemic awareness skills were found with younger readers of nonalphabetic writing systems, but not their older counterparts (if the older subjects were taught kana and characters through a different method of instruction - or at home - or if the older subjects were far enough removed from their school-days instruction that their phonemic awareness skills had atrophied).

2.3.4. Phonemic awareness and reading across alphabetic orthographies

This chapter has highlighted a number of key findings related to phonemic awareness and alphabetic literacy. Yes, most of the research on this connection has focused on emerging readers of English. We know from the previous sections that illiterates in non-alphabetic literates struggle with phonemic awareness. What about alphabetic literates in languages other than English? Shouldn’t the theory predict the same strong connections between phonemic awareness and reading skill in those groups?

Carvalos et. al. (2012) conducted a large-scale longitudinal study of learning to read in four languages: English, Spanish, Slovak, and Czech. As expected, phonemic awareness was a predictor of reading ability in all languages. Haigh et al (2011) studied nearly 600 English-dominant kindergartners in French immersion programs. English phonemic awareness (as measured by phoneme manipulation) was a significant predictor of reading ability in English and French reading ability in second grade, suggesting a cross-linguistic, transferrable skill. And Ziegler et. al. (2010) found that among second graders learning to read five different alphabetic orthographies (Finnish, Hungarian, Dutch, Portuguese, and French), phonological awareness was the main factor associated
with reading. All of this suggests that the findings about phonemic awareness and reading in English translate to reading in other languages with alphabetic writing systems.

However, a deeper examination of each study uncovers some interesting differences. First, in the Haigh et. al. study, French phonemic awareness did not predict English reading skills, even though the reverse was true. In the Zeigler et. al. study, phonemic awareness effect was significant stronger in languages with less transparent orthographies.

These findings may be explained by the “psycholinguistic grain size” theory (Ziegler & Goswami, 2005) which proposes that children’s decoding skills are language-specific. In phonologically opaque (or “deep”) orthographies, such as English, decoding demands far more orthographic information to determine meaning. This necessitates larger “grain sizes” such as syllables, rimes, and even morphemes. Children learning to read these languages may be slower to acquire phonemic awareness, due to inconsistency between grapheme/phoneme correspondences, but ultimately that awareness becomes more important to the reading of new and unfamiliar words. Children acquiring reading in languages that have high orthographic consistency (or a “shallow” orthographies), such as Greek and Spanish, are quicker to acquire phonemic awareness. However, phonemic awareness ultimately has a weaker (though still significant) association with reading than it does in languages with deep orthographies (Ziegler & Goswami, 2005, 2006; Goswami, 2010) For additional examples, see Caravolas & Landerl (2010) for a
discussion of Czech vs. German, Pattamadilok et al. (2010) for a comparison French and Portuguese, and Branum-Martin et al. (2012), for a review.

2.4. Summary & implications

In this chapter, phonemic awareness and syllabic awareness were defined and key findings from phonemic awareness research were presented. To recap the salient points thus far:

1. Phonemic awareness is a predictor of reading ability in children. This is true across alphabetic orthographies, though the strength of the relationship varies based on orthographic depth.

2. Syllabic awareness is not a predictor of reading ability in children.

3. Phonemic awareness development is associated with alphabetic experience; it is not a developmental milestone, as it is lacking in illiterates and those who read non-alphabetic orthographies.

4. Syllables are more accessible units than phonemes; syllabic awareness precedes phonemic awareness and may exist in its absence (e.g., in preliterate children and illiterate adults).

The next chapter reviews what we know – and don’t know – about phonemic awareness and reading ability in adults.
3.0. ADULTS, PHONEMIC AWARENESS AND READING

This chapter summarizes research that is relevant to the issue of phonemic awareness in literate adults. The connection between phonemic awareness and reading ability established in the previous chapter cited research on emerging readers. In testing mature readers with years of alphabetic exposure, we must ask:

1. Given their reading experience, do adults continue to process syllables differently from segments?

2. To what degree does orthographic information influence phonological processing?

3. To what degree does phonological information influence orthographic processing?

3.1. Adult processing of syllables vs. segments

The studies cited the previous chapter suggest that the processing of syllables and the processing of segments are fundamentally different; syllabic awareness develops before (and in the absence of) alphabetic experience (as demonstrated by studies with preiterate children and illiterates) but the latter seems to require alphabetic or pseudo-alphabetic experience. Mehler, Dommergues, and Frauenfelder (1981) were among the first to argue that that the syllable – rather than the segment - is the basic unit of speech processing. In their seminal work, French participants were asked to listen to various words, monitoring for a target syllable (for example, /pa/). Upon hearing the target syllable in an input word, they were to press a button, indicating whether a match had been detected. The experimenters considered two alternate theories of processing: either the participants were processing input words phoneme-by-phoneme or syllable-by-
syllable. If the participants were using the phoneme as their basic unit of processing, there would be no difference in the time it took participants to detect the target in words beginning with identical phoneme sequences. Consider the example below:

<table>
<thead>
<tr>
<th>target sound:</th>
<th>p...a...</th>
<th>p...a...</th>
</tr>
</thead>
<tbody>
<tr>
<td>input:</td>
<td>p...a...l...a...s</td>
<td>p...a...l...m...i...e...r</td>
</tr>
<tr>
<td>result:</td>
<td>match</td>
<td>match</td>
</tr>
</tbody>
</table>

In both cases, the match occurs two phonemes into the target word, so detection of /pa/ in pa.las should be no faster or slower than detection of /pa/ in pal.mier. This is not what Mehler et. al. found, however. Participants were significantly slower in detecting the /pa/ in pal.mier (that is, detecting a CV target in an input word beginning with a CVC syllable). These results are quite understandable if the syllable is viewed as the basic unit of processing:

<table>
<thead>
<tr>
<th>target sound:</th>
<th>pa</th>
<th>pa</th>
</tr>
</thead>
<tbody>
<tr>
<td>input:</td>
<td>pa...las</td>
<td>pal...mier</td>
</tr>
<tr>
<td>result:</td>
<td>match</td>
<td>mismatch</td>
</tr>
</tbody>
</table>

Since the target /pa/ matches the first syllable in pa.las, but not in pal.mier, the match in the first is detected significantly faster. Mehler et. al. conclude that the only logical solution is that participants process words in terms of syllables and not phonemes.

Cutler, Mehler, Norris, and Segui (1986) attempted to replicate the Mehler et. al. task in English, but ran up against a brick wall, unable to replicate the results. They concluded that because of ambisyllabic in English (see section on ambisyllabic in
the next chapter), syllables in English are ambiguous, and a wholly syllable-based
processing strategy does not serve English listener. Rather, they use a Metrical
Segmentation Strategy (MSS) (Cutler & Norris, 1988). In the initial metrical
segmentation work, Cutler & Norris found that participants detected a word (e.g., mint)
embedded in a bisyllabic nonsense word more slowly when the word had two strong
syllables (mintayve) than when it had a strong and a weak syllable (mintesh). They
theorized that this is because they syllabify words at the beginning of strong syllables
(/mn.tayv/), which creates a mismatch between the parsed syllable /mn/ and the target
/mnt/.

So, this begs the question of whether or not the syllable as a unit plays a universal
role in speech processing, or whether a language’s specific phonological pattern dictates
the unit of segmentation. Do French listeners process via syllables, Japanese listeners by
morae, and English listeners by type of syllable? In the decades since the MSS work,
Cutler and colleagues – among others – have concluded that, “the syllable does have a
language-universal part to play in speech processing, just as [Mehler] argued two decades
ago.” (Cutler, McQueen, et. al. 2002, p.181, emphasis mine). One conception of this
“language-universal part” is the Possible Word Constraint, which is defined below.

The Possible Word Constraint

McQueen et. al. (1994) set out to investigate the process of word recognition,
rather than mere syllable matching, as in the earlier Mehler et. al. study. They used a
“word-spotting” task to explore how listeners recognize words in a speech signal.
Participants were asked to listen for target words embedded in two types of stimuli: the beginnings of potential real words and nonsense strings. For example, participants were asked to spot the word mess /mɛs/ in the strings /dəmɛs/ and /nəmɛs/; the former is the beginning of a real word in English (domestic), but the latter is not. Participants exhibited slower response times and higher error rates when the nonsense string was the beginning of a longer real word than when the string could not be continued to form a real word; from this, McQueen et. al. concluded that potential words compete with the embedded words in the word recognition process, making their detection more difficult.

Norris et. al., (1997) revisited the “word-spotting” experiment. While McQueen et. al. explored the processing of words embedded in potential words vs. nonwords, Norris et. al. explored the processing of words embedded after a syllable vs. segment boundary. Modeling their task after McQueen, they asked listeners to spot a word (e.g. apple) in two different types of nonword stimuli. In the first type, participants would need to strip off an initial consonant (/f/) in order to detect the word (e.g. fapple) and in the second, participants would need to strip off an initial syllable (/vʌf/) in order to detect the word (e.g., vuffapple). They found that participants were slower and less accurate when the target was embedded after a segment boundary (f-apple) than after a syllable boundary (vuff-apple). They conclude that this is because listeners initially segment the speech signal by looking for word boundaries; since /f/ alone is an impossible word in English, but /vʌf/ is a possible word (if not actual) word of English, listeners find it more
difficult to find words in stimuli like *fapple* because they have a bias against placing a word boundary at a point in the speech signal that would result in an impossible word.

They label this finding the Possible-Word Constraint:

> In nearly all languages it is the case that a single consonant cannot form a lexical word. This is certainly true of English; and if listeners were to incorporate this principle in some manner into their analysis of continuous speech input, then they might have at hand a solution to the problems posed by out-of-vocabulary items and corrupted input. That is, they might be able to reject *four* plus *f* as an account of *fourf* not just because *f* is not a member of their vocabulary, but because *f could not ever* be a member of their vocabulary. (p. 201)

The Possible Word Constraint is not intended to be language-specific. The syllables that listeners parse are *possible* words, not *actual* words (e.g. the /vʌf/ in *vufapple* is not an actual word of English, but it is a possible word, phonologically speaking). But, the PWC takes things one step further: the syllables by which we parse are possible words in human language, not only in the language of the listener. Thus, it is a universal constraint on speech processing. A few follow-up studies provide evidence that confirms this.

Norris et. al. (2001) found that English-speaking participants performing the word-spotting experiment identified *canal* /kʰənəl/ as a word in /zəkʰənəl/ more rapidly and accurately than they did in /skʰənəl/. This is noteworthy because, in English, /zəl/ is not only a non-existent word in English, it is an impossible word, as English disallows words which only consist of a consonant plus a lax vowel. So, even though the syllable that participants had to strip off /zəkʰənəl/ is an illegal word in English, the syllable (as a
phonological unit) was accessed more readily than the segment (that is, participants found it easier to strip off /ze/ than /s/).

Similarly, Cutler, Demuth et. al. (2002) found that even in languages where monosyllabic words do not exist, listeners employ the Possible Word Constraint. In Sesotho, as in many Bantu languages, well-formed words are minimally bisyllabic. Thus, the syllable /ro/ does not (and cannot) exist as a word in Sesotho. The word-spotting experiment was administered to Sesotho listeners. They were asked to spot a word (e.g. alafa, ‘to prescribe’) in three different contexts: one which would require them to strip off a bisyllabic nonword (“pafoalafa”), a syllable (“roalafa”) or a single consonant (“halafä”). Participants were able to spot a words more quickly and accurately in the syllabic than in the consonantal context, which is consistent with the English language findings cited above. However, it was also the case that there was no significant difference in participants’ ability to spot a word in the monosyllabic vs. bisyllabic context; they were no better at stripping off /pafo/ (a legal-but-not-actual word in Sesotho) than /ro/ (an illegal word in Sesotho).

So, in both English and Sesotho, the type of syllable was shown to be irrelevant to the Possible Word Constraint; what is important is the syllable as an abstract concept. The PWC is based on the notion of the the syllable as a theoretical “possible word,” not a possible word in the language of the subject. Cutler, Demuth et. al. conclude:

The word recognition system operates in a universal manner: The aim is optimally rapid and efficient identification of the words making up a running speech signal. Words supported by the signal are automatically activated; spuriously present ones can often be identified at an early stage
and eliminated as inherently unlikely. What makes them unlikely is that they leave an unusable residue between their edge and the nearest boundary. That boundary may have been set by language-specific factors (stress, sequence restrictions, etc.); but the viability of the residue is tested against a universal criterion whereby the residue must be, minimally, a syllable. (p. 262)

The last sentence of the quote is important: “That /word/ boundary may have been set by language specific factors.” Cutler and fellow PWC supporters do no propose that the PWC supplants language-specific strategies in word recognition, but rather works in concert with those strategies. They acknowledge that although there are crosslinguistic differences in speech processing due to the different phonological structures of languages; word-boundary clues may be provided by phonotactics or the rhythmic structure of the language. English speakers will split /vl/ across a word/syllable boundary because it is an illegal onset in English, and use a Metrical Segmentation Strategy whereby onsets of strong syllables are parsed as word boundaries. However there are also fundamental commonalities in speech segmentation, i.e., the universal role of the syllable. In processing speech, listeners employ both language-specific and language-universal strategies.

The PWC has its critics. Hanulikova (2008) tested the PWC on German and Slovak speakers, and found that Slovak speakers’ results did not conform to the PWC. In Slovak, single consonants can serve as function words (for instance, /g/ means ‘to’). Slovak speakers found it easier to segment the work ruka when it was preceded by a consonantal word context (e.g., gruka), than when it was preceded by a consonantal word (e.g., truka) or a syllable (e.g., dugruka). Dumay (2012) conducted an auditory priming
experiments in which the targets were either the final syllable or final syllable minus one phoneme; the study did not find evidence for syllables as a unit of speech perception when they were in word-final position. Despite these criticisms, there are some consensus points around the processing of syllables, cross-linguistically:

- Syllable are a \textit{more accessible} unit than phonemes
- Syllabic awareness develops before phonemic awareness in alphabetic literates
- Syllabic awareness can exist in the absence of phonemic awareness, while the reverse is not true)

The results of the tasks in the next chapter, in which participants are asked to perform tasks that require participants to delete/substitute/reverse segments and syllables, will test whether syllables are significantly more accessible units than syllables. If they are, we would expect that its detection and manipulation are basic abilities, and that subjects will perform significantly better on syllable-based tasks.

\textbf{3.2. Orthographic interference in phonological processing}

Most phonemic awareness research has been conducted on preliterate children, illiterates, or literates in nonalphabetic orthographies: those with little or no experience with alphabets. However, there is evidence that knowledge of orthography, or of a particular orthography, can affect performance on various phonological tasks. Since the subjects in this project were all literate adults, we must examine the role that orthographic knowledge might play in a phonemic awareness task. This section explores the role that orthographic information plays in phonological processing.
The work discussed in Chapter Two makes it clear there is a positive correlation between phonemic awareness and reading ability in studies with children, and indicates that phonemic awareness helps children break the alphabetic code, and go on to become better readers. This relationship manifests itself in the ability to perform phoneme manipulation tasks, and in the encoding of grapheme-phoneme relationships. However, once adults become fluent readers, they may actually be hindered by knowledge of the alphabetic code when performing phonological tasks. Several studies which have addressed this issue are discussed below.

Tanenhaus, Flanigan & Seidenburg (1980) presented subjects with a series of auditory word pairs, and asked subjects to ascertain whether or not the pairs rhymed. Some of the rhyming pairs were orthographically similar (like TURN/BURN) and some were orthographically distinct (like TURN/LEARN). The main finding of the study was that orthographically distinct pairs of words took much longer to identify as rhymes than pairs that were spelled alike. Thus, at some point between the time when subjects are presented with auditory stimuli and when they press a response key, orthography interferes.

Zecker et. al. (1986) also found that it took subjects considerably longer to judge a rhyming match in orthographically dissimilar pairs (DIRT/HURT) than in an orthographically similar pairs (GLUE/CLUE). Moreover, they found a significant interaction between ear of stimulus presentation and the orthographic similarity of stimulus items; the response time effect was significantly greater when stimulus items were presented in the right ear (i.e. the left hemisphere) than the left ear. They conclude
from this that orthographic and phonological information are integrated in the left hemisphere of the brain.

More evidence for orthographic interference in phonological processing comes from Taft & Hambly (1985), in a syllable matching study. Subjects were presented with pairs of auditory stimuli - a syllable and a word - and asked to determine whether the syllable was contained in the word. Subjects performed particularly poorly on pairs such as ANK/ANXIOUS (/æŋk/-/æŋkʃəs/), pairs which were identified by the researchers as cases in which orthographic interference was likely. They argue that though /æŋkʃəs/) is spelled a-n-x..., /æŋk/ is "spelled"\(^1\) a-n-k. Due to an orthographic mismatch ("x" vs. "k"), subjects determined that there was no match, even though, on the basis of phonology, a "yes" response was expected.

How are these examples of orthographic interference to be interpreted? As Taft and Hambly note, "the interpretation that one favors ultimately depends on how dominant a role one wishes to ascribe to orthography in spoken word processing" (T&H, p. 331). This is best illustrated using a lexical access model, such as the simplified sketch Forster’s Lexical Search Model (Forster 1976; 1990), given below:\(^2\)

1. That is, a-n-x... is the orthographic representation they would construct is a-n-k.
2. Note that the semantic access code has been omitted here for the sake of simplicity.

```
<visual stimulus>  <auditory stimulus>
↓               ↓
orthographic access code  phonological access code

MASTER LEXICON
master lexicon entry
(orthographic information/phonological information)
```
According to the strictest interpretation of the Forster model, orthography plays a minimal role in spoken word processing. Given an auditory stimulus, a purely phonological code is used in lexical access. Only after access has taken place is orthographic information about that word (stored in the Master Lexicon entry) available.

An alternative to the Forster model would ascribe a dominant role to orthography in spoken word processing. Contra the Forster model, such a model of lexical access would look something like this:

![Diagram showing the interaction between auditory stimulus, orthographic access code, phonological access code, and Master Lexicon]

with both orthographic and phonological codes involved in the access of an auditory target. A third alternative lies somewhere in between these two extremes, with orthographic information neither ignored during auditory word processing nor given the same importance as phonological information.
Zecker et. al. argue that orthographic interference in tasks with auditory stimuli is the result of automated graphophonetic (sound-symbol) rules that children learn as beginning readers. What appears on the surface to be orthographic interference during access is really the result of "automatized" comparisons of post-access activated spellings with their pronunciations. To make this more concrete, consider the two tasks discussed above. In the rhyming recognition task, the stimuli (LEARN/TURN; TURN/BURN) are accessed via a purely phonological code, but once the words are accessed, their Master Lexicon entries, orthographic representations and all, are activated. A post-access check ascertains that l-e-a-r-n and t-u-r-n are not spelled the same, even though "automatized" sound spelling rules (which would say something like, e-a-r-n sounds like /ern/, u-r-n sounds like /ern/) predict a match. This contradictory information results in a longer reaction time. The same is true in the ANK/ANXIOUS case. Once ANXIOUS is accessed, its spelling is available and will thus cause interference in the form of a mismatch when compared with the speech signal ANK.

A second possibility is that orthographic interference results from "orthographic recoding" (application of on-line sound-to-spelling conversion rules), analogous to "phonological recoding" in written word recognition (see Taft, 1991 and others, as well as the discussion in the next section). It is a dual-route access model, whereby both phonological and orthographic codes work in tandem in auditory word recognition. So, just as a child learning to read learns a rule that the letter ‘s’ sounds like /s/, that same child, in learning to spell, learns that "long i" (/ai/) is spelled 'i...e.' Dupoux & Mehler (1992), in their analysis of French phoneme detection tasks, provide arguments that "not only is an orthographic code available when listening to speech....but this code is
available on-line" (p. 65). They attribute differences in performance on syllable monitoring tasks by literates and illiterates to the fact that an on-line orthographic code, which results in orthographic interference among literates, is not available to the illiterates. If it is the case that orthographic recoding happens on-line, this is what happens with the rhyming task:

![Diagram](image)

**Figure 3.3: On-line orthographic recoding of orthographically similar words**

In the case where two words are pronounced alike, the sound-spelling conversion rules will yield the same spelling for both words. If the words are in fact spelled alike, this will not be a problem once the words are accessed. On the other hand, consider the case in which two words pronounced alike are spelled differently:

![Diagram](image)
Figure 3.4: On-line orthographic recoding of orthographically dissimilar words

Again, since the words are pronounced alike, orthographic recoding would spell them in the same way. The outputs of two possible spelling-sound conversion rules are listed above. No matter which rule is chosen, such recoding would cause interference (since *lurn and *tearn would not be listed in the lexicon).

A third possibility for the role of orthography in auditory word recognition, which lies somewhere in between the dominant and minimal roles discussed thus far, is that phonological and orthographic representations of words are integrated as a learning heuristic. The access route for auditory words is neither purely phonological (latter tapping into orthographic information), nor orthographic and phonological in parallel, but rather involves some an integrated code. Lexical access, in this model, taps into what Taft and Hambly call "orthographically influenced phonological representations" (Taft & Hambly, 1985). These might include something like the “spelling pronunciations” that Lorenson (1993) found: subjects have trouble classifying /izlænd/ (for island) and /kolonel/ (for colonel) as nonwords, apparently because these pronunciations warrant a pseudo-lexical entry (an "orthographically influenced phonological representation”) in the brain.

So, orthographic information does interfere with performance on phonological tasks, be it through phonologically accessed orthographic representations, orthographic recoding, or orthographically influenced phonological representations. The next two
sections explore the degree which phonological information intervenes when processing an orthographic stimulus (that is, when reading).

3.3. Direct Access & Guessing Games: A minimal role for phonemic awareness

Until relatively recently, a predominant view of adult reading was that skilled readers were whole-word readers. Writing in the early 70s, Smith (1973) argued (at the time, quite influentially) that reading-as-recoding of graphemes into phonemes is wholly inefficient in a language like English, which harbors many inconsistencies in sound-symbol correspondence (i.e. mint/pint, gave/have). This theory has the advantage of intuitive appeal. Certainly, someone who “sounds out” words when reading presents as an immature, unskilled reader. Whole word reading seems quicker and more efficient than the alternative. Smith posited a “direct access” model of word recognition, whereby word meaning is derived directly from print, unencumbered by phonological information. This argument was bolstered by the observation that skilled readers of English are able to easily read irregularly spelled words, and these are words which can’t be accessed by a purely phonological route.

Goodman (1993) and whole-word advocates characterize the process of skilled reading as a “psycholinguistic guessing game” in which attention to the details of words (i.e., the grapheme-phoneme correspondence) is secondary to attention to context. In Goodman’s view, reliance on context is the most important factor in skilled reading. Smith, Goodman and their supporters advanced the argument that reading happens too
rapidly to be based primarily on mastery of complicated and inconsistent pronunciation rules.

Nevertheless, Goodman and other whole-word theorists concede that all alphabetic literates are phonemically aware. Goodman (1993) says that readers have "three systems of information to bring to any text - graphophonic, syntactic and semantic - and that each one supports the other two. In the course of making sense of print, we use all three systems" (Goodman, p. 53). While whole language theorists believe that readers keep their primary attention focused on comprehension when making sense of a text, they concede that they “shift their focus to the detail of the text and the cue systems they are using... when comprehension begins to break down” (p. 83). According to this view, semantic information provides the most important clues used in reading and drives the reading process, but the specifics of a particular situation (difficulty, strangeness, vocabulary, familiarity, nervousness, etc.) may affect which information is used, and may require the reader to rely on his or her phonemic awareness skills from time to time.

Thus, even those most committed to the view of reading as whole-word processing fit phonemic awareness into the schema, though it plays second fiddle to other processing mechanisms. They argue that competent (adult) readers read differently than beginning readers, paying less attention to the details involved in reading (like the correspondence between letters and sounds) and more attention to meaning; context clues (to a greater degree than graphophonic rules) are used when reading unfamiliar words. Readers only resort to graphophonic rules as a last-ditch effort, only when all other avenues (whole word recognition and context clues) fail. Thus, phonemic awareness is
not a primary reading skill; once readers have acquired a baseline level of phonemic awareness that can get them out of sticky reading situations, they become comprehension-based whole word reading.

However, competent, literate adult readers frequently encounter reading situations that require the novel implementation of phonemic awareness skills. Consider the following:

- **Unknown words.** Example: A newscaster, seeing an unfamiliar name for the first time (e.g., *Mahmoud Ahmadinejad*), has no choice but to “sound out” the name, this implementing phonemic awareness skills and the alphabetic code.

- **Known words unfamiliar in print form.** Example: A reader comes across the word *imbecile* for the first time in print, and realizes upon sounding it out that it is the word he recognizes in spoken form (/ɪbɪsəl/).

- **Partial words.** Example: A crossword puzzle aficionado does the *New York Times* crossword every week. In doing so, she often has to strip phonemes off words, to see if they meet certain criteria. For example, if the answer is _e_ert and the clue is obscure or ambiguous to her, she will only be successful in solving the puzzle if she can think of words that fit the schema (*desert, revert*, etc.)

The readers in each of these situations are competent readers, and yet their day-to-day reading experiences regularly invoke phonemic awareness skills. Moreover, a growing body of reading research indicates that competent readers focus on letter and phoneme-level detail when reading.

Evidence has mounted over the last four decades that the process of reading is much more complicated than the models of Smith or Goodman would indicate. Specifically, there is clear experimental evidence that skilled readers do pay attention to the details of print when reading, and that phonological recoding is a crucial component
of the lexical access process. Ashby & Rayner, in a 2005 review of literature on skilled readers, argue that, “the sum of evidence from word-identification experiments and eye-movement experiments indicates that skilled readers process text thoroughly and automatically from the letter level on up. Modern reading research does not support the claim that skilled readers engage in a psycholinguistic guessing game.” (Ashby & Rayner, 2005, p. 57). This research is summarized in the next section.

3.4. **Interactivity: A significant role for phonemic awareness**

Stanovich (1983) was the first to argue that in adult reading the ability to apply grapheme-to-phoneme conversion rules is crucial, since it may have to take over at any time when other clues fail (losing your place on a page, etc.). In his view, phonemic awareness skills must remain sharp in competent adult readers, as they may be called upon at any time, not only as a last resort. O'Brien (1988) summarizes the difference between the whole language (comprehension) view of reading above and this interactive (comprehension & phonics) theory as follows: "the [former] holds that readers rely less on graphic and graphophonic information and more on context as they become more adept at reading [whereas] interactive positions of reading [postulate] that multiple information sources are used in creating meaning from texts and that the sources used at any given time may be controlled by a process that compensates for processing weaknesses" (O'Brien, p. 380).

Below, evidence is presented from word-identification, eye-movement and other studies that speak to the role of graphophonic detail in adult reading.
3.4.1. Word Identification Studies

Even at the time of Smith’s early writings, there was experimental evidence showing that readers pay attention to the details of words when reading, rather than processing words as wholes. Reicher (1969) and Wheeler (1970) both demonstrated that subjects are better able to identify letters when they are embedded in words than when they are viewed in isolation or embedded in nonwords, a phenomenon that would come to be known as the “word superiority effect.” Subjects more accurately identified the letter “k” as being in the stimulus WORK than in the nonword WOSK or the single letter string K. Because this finding held for letters no matter what their position (beginning, medial, end) the researchers concluded that readers process all letters of a word when reading and do not simply treat a written word as an impenetrable whole.

Work by Van Orden and colleagues nearly two decades later also debunked the direct access model, but via a different experimental technique. While Reicher & Wheeler showed that readers pay attention to the individual letters which comprise the written word, Van Orden showed that readers use phonological information to access meaning. Van Orden (1987) presented subjects with semantic decision task, e.g. Is [stimulus] a member of the category ‘food’? The written stimuli were either true examples of the category (e.g., MEAT), homophones (e.g., MEET) or orthographic neighbors (e.g., MOAT). He found that subjects were significantly more likely to falsely identify the homophones as category exemplars than the spelling controls, indicating that they were using phonological recoding to access meaning. O’Brien, et. al. (2013) and
Van Orden, et. al. (1988) found the same effect for pseudo-homophonic stimuli (i.e., SUTE as a stimulus for the category “clothing”). Subjects were significantly more like to identify pseudohomophones as members of a category than the orthographic nonword foils. This, the researchers argued, showed that word recognition progresses from spelling to sound to meaning, not from spelling to meaning directly. Moreover, both real homophones (i.e. ROWS for ROSE) and pseudohomophones (SUTE for SUIT) produced the same error rates, which was interpreted as evidence that phonological recoding happens automatically for all printed stimuli regardless of lexical status (word vs. nonword). Jared & Seidenberg (1991), in a series of six experiments, replicated many of the Van Orden findings about the role of phonology, but found that the phonological recoding effect seemed to hold only for low-frequency homophones (FLEE for FLEA) but not for high-frequency homophones (SUN for SON).

Using a different methodology, the masked backwards prime, Perfetti et. al. (1988) also demonstrated that phonological recoding of words happens very early in the lexical access process. In backwards priming, subjects are faced with a lexical decision task. They are presented with a target word followed by a “backward” (disruptive) prime; both the target and prime are viewed for a very short duration (55 milliseconds) which is understood to be less than the duration required for full lexical access (Rayner, 1998). Perfetti et. al. presented subjects with a target word (i.e. MADE) followed with three types of primes: a spelling-related nonword (MARD), a homophonic nonword (MAYD), and a nonword control. They found that both the orthographically-related and phonologically-related primes facilitated lexical decision relative to the control, but that
the effect of phonological similarity was greater than the effect of orthographic similarity. From this, they concluded that phonological recoding occurs prelexically (as judged by the short duration time of the prime) and automatically during lexical access. Perfetti & Bell (1991) conducted a similar experiment, but manipulated the exposure times of the pseudohomophonic primes in a series of experiments. They found that phonemic priming effects were found in durations as short as 45 ms; a briefer duration than previously demonstrated and one which strongly supports a process of early phonemic activation prior to word identification.

Lukatela & Turvey (1994) also manipulated prime exposure times to determine when phonological information kicks in during the lexical decision process. Their work involved a forward masking experiment. A target (i.e., FROG) was primed by a semantically related prime (e.g., TOAD) or a semantically unrelated homophone (i.e. TOWED). Subjects were exposed to the prime for either short (50ms) or long (250ms) exposure times. Although the semantic primes facilitated lexical decision at both duration times, the phonological primes only facilitated decision in the 50 ms condition. This is consistent with the Van Orden 1987 account of word recognition which posits that lexical access is initially phonological, and that homophones are disambiguated at a later stage of process (i.e., 250 ms) by a spelling check.

Recent studies have used the measurement of event-related potentials (ERPs) (Ashby, 2010) and whole-head magnetoencephalography (MEG) (Wheat et. al., 2010) to try to pinpoint when phonological information is accessed; both of these studies provide
further evidence that phonological access is a key component of skilled reading and is accessed early in the word recognition process (i.e., within 100 ms).

3.4.2. Eye-Movement Studies

Research on eye movements has been used to determine when and how phonological information intervenes in the process of reading. By studying fixations of about .25 seconds in between “saccades” (rapid eye movements that a natural part of the reading process), researchers have determined what details readers attune to when reading a text. Decades of research have uncovered some commonalities; for instance, in English, the perceptual span is about 7-8 letters to the right of and 3-4 letters to the left of the fixation, readers process all words though they may fixate on only one, and lexical access is typically associated with approximately 250 milliseconds fixation (though it may be shorter for more common words) (Rayner 1998, 2009).

In a classic eye movement study, Rayner et. al. (1998) asked subjects to read short passages of text that contained either a target (MEAT), its homophone (MEET), or a spelling control (MOAT). Target homophones were either predictable or not predictable from the context (which is important because fixations are known to be longer when the target is not predictable). Rayner et. al. found that when words were not predictable from context, fixations on homophones (MEET for MEAT) were the same duration as fixations for targets (MEAT for MEAT) and significantly shorter than fixations on spelling controls (MOAT for MEAT). In other words, the eye movement research indicated that subjects did not initially recognize a misspelled homophone (MEET) as a faulty representation of
the homophonic target (*MEAT*). This finding supports Van Orden’s model of lexical access, whereby the phonological representation of a word is activated immediately by the orthographic signal, and where the orthographic information is available after lexical access. That is, eye movement research supports the 1987 Van Orden finding that pseudohomophones are mistaken for the words they sound like in reading, indicating that readers are paying attention to the phonological details of text and not simply accessing words via a direct access orthography-to-meaning route.

Sparrow & Miellet (2002) replicated the Rayner et. al. findings in French. Subjects were asked to proofread a text; they found that fixation durations on pseudohomophones and correct targets were statistically equal, but significantly less than those for spelling controls.

More recently, Ashby et al. (2005) set out to compare the reading strategies employed by average vs. highly skilled readers, drawing on the research findings cited above. The factors which were manipulated in the fixation study were the predictability of a target (*e.g. He scraped the cold food from his dinner plate before washing it* vs. *John stirred the hot soup with the broken plate until it was ready to eat*) and the frequency of the target (*He scraped the cold food from his dinner plate before washing it* vs. *He stirred the hot soup with the broken spoon until it was ready to eat*). They found that highly skilled readers read high-frequency words 17 ms faster than average readers, but that there was no difference in low-frequency words (298 ms for the highly skilled readers and 295 ms for the average readers). An analysis of spillovers (reading ahead) and regressions (re-reading) indicated that that average readers were more likely than skilled...
readers to skip low-frequency words when reading; that is, they were more likely to rely on context to support their recognition of predictable, low-frequency words. This finding is entirely at odds with whole word/direct access models of reading, which suggest that the best readers rely on context when reading. Rather, the eye-tracking research shows that the best readers are less like to skip words and more likely to pay attention to the details of words.

Recent work on phonological processes in word recognition supports these findings, and suggests that children progress from being whole-word readers (in the very early stages) to phonetic readers of novel words. Once words are familiar, readers do not revert to whole-word reading; rather, it is the phonological pattern of a word (processed within in the first tenth of a second of seeing it) that facilitate word recognition (Ashby & Rayner, 2012; see also Joseph et. al., 2013; Ashby et. al., 2012).

3.4.3. Miscues

O'Brien (1988) tested the comprehension-driven reading vs. interactive reading theories in a study based on the analysis of reading miscues, and found support for the interactive theory. Miscues are the mistakes that people make in reading aloud. Not all mistakes are created equal, though. Some mistakes indicate attention to meaning (saying, “She dunked a doughnut” when the text says, “She dunked a muffin”), whereas others indicate attention to graphophonic information (“She dunked a muffler”). One of the assumptions of miscue analysis is that the type of miscue a reader makes indicates the level of his or her comprehension: "readers who make semantically and syntactically
acceptable miscues that do not result in meaning loss are assumed to be comprehending a

O'Brien conducted an experiment on seventh graders designed to test the

O'Brien’s results indicate that readers pay the least attention to context when

"the broadest interpretation of such conflicting results across passage content is that oral

The interactive theory, by which
readers - even good readers - often rely on graphophonic conversion (and, by extension, phonemic awareness) is better able to explain O’Brien’s results.

There are several survey articles and studies on the predictability of text from semantic and syntactic clues that provide supporting evidence for O’Brien’s conclusions that reading is an interactive process, and not based predominantly on semantic and syntactic cuing. For instance:

1. Across a number of studies, the probability of a reader predicting the next word in a passage from semantic and syntactic information was between .20 and .35, hardly a safe bet as a main strategy in reading comprehension (Stanovich & Stanovich, 1995), and

2. The words which readers are most able to correctly predict are function words\(^3\), not words bearing semantic content (Gough, 1983), a finding which is difficult to reconcile with the comprehension-driven theory of reading.

O’Brien concludes that the results of his miscue study conflict with the whole language view of reading, and can be better explained by an interactive view of reading, whereby readers use different information sources at different times to fill in processing "gaps." One such information source is graphophonic information. The O’Brien and Ashby studies on good readers then provides preliminary evidence that a connection between phonemic awareness and reading may be found in adults, just as it has been with children.

3.4.4. Direct Studies

Despite the overwhelming evidence that skilled readers focus on graphophonic information when reading, there is little research which speaks to any direct connection

\(^3\)This may also help explain why in studies in which normal, literate adults are asked to cross out all occurrences of a given letter in a passage, they frequently miss the letters in function words.
between reading ability and phonemic awareness in literate adults. Wagner et. al. (1997) conducted a longitudinal study of 216 children in which the correlations between phonemic awareness and reading ability were examined over time, as the children progressed from kindergarten through 4th grade. Each year, the children’s phonemic awareness skills, word-level reading skills, and vocabulary were assessed. Individual differences in phonemic awareness were correlated with individual differences in word-level reading for every time period examined. Differences in phonemic awareness skills (i.e., ability to perform on tests like "Say the word cup. Now tell me what word would be left if I said cup without saying /k/.") were associated with reading ability (as measured by the Woodcock Reading Mastery Test—Revised (Woodcock, 1987)) at each time period in which the children were examined. Moreover, the difference in phonemic awareness skills among students was found to be remarkably stable from year to year.

Ben-Dror et. al. (1995) compared the phonemic awareness abilities of adults who are literate in Hebrew (in which graphemes generally correspond to CV units) vs. adults who are literate in English. In an experiment in which subjects were asked to delete the initial consonant of a word, the English readers outperformed their Hebrew-reading counterparts. From this, the researchers conclude that, “A writing system in which letters represent single phonemes has apparently long lasting effects that extend to adult readers as well as children” (Ben-Dror et. al., 1995, p. 139).

Some studies have found that decoding (ability to read unknown words and/or pseudowords) is related to reading comprehension in adults (Lundquist, 2004; Ransby
and Swanson, 2003); this is an *indirect* indicator that adults employ phonemic awareness when reading.

Though all of these studies hint at the possibility of a phonemic awareness/reading connection in literate adults, none examined it directly.

### 3.5. Summary

Several decades ago, the direct access view of reading, which hypothesizes that readers directly map a word’s orthography to its meaning in the lexical access process, was widely accepted. The direct access model had the advantage of intuitive appeal; the process of computing meaning by phonological recoding (rather than their spelling) was viewed as a computational onus, an extra step that was superfluous at best and misleading at worst (in the case of words with irregular sound/spelling correspondences).

Frost (1998), in a review of the word recognition literature, much of which is cited above, argues for the “central and primary role of phonological processing in word recognition” (Frost, 1998, p. 71). Others (Coltheart, 1978; Coltheart, 1993; Papp & Noel, 1991, Coltheart et. al. 2001) have posited “dual-route” models whereby readers use *either* orthographic or phonological information to access word meaning, calling upon a phonological route to process lower-frequency spelled words, unfamiliar words and nonwords, but a direct visual (orthographic) route to process high-frequency and irregularly spelled words. In some dual-route models, lexical access is a ‘race’ between the two systems, with the more efficient system winning out depending on the characteristics of the written input. So, the phonological access route might win the race
for *mint*, but the orthographic access route would win for *pint*. Seidenberg (1992) observed that while English does contain a large number of words with irregular spelling sound correspondences, they tend to be high-frequency words, short words, and thus words which are learned early and easily. Because of this distributional tendency for irregular words in the language, Seidenberg argues, they alone shouldn’t be treated as the basis for a model of lexical access.

More recently, connectionist models of reading (Seidenberg & McClelland, 1989; Harm & Seidenberg, 2004; Seidenberg, 2005) have gained attention. In connectionist models, orthographic and phonological information are not processed independently of one another, nor are these direct-access and recoding routes in a race; rather, all orthographic, phonological and semantic information exists in layers which continually interact with each other in the computation of meaning.

What is clear is that the current models of reading ascribed to by linguists, educators and reading researchers all acknowledge that phonological recoding plays a significant role in the reading process carried out by skilled, literate, adult readers; the direct access view has been thoroughly debunked. As such, phonemic awareness research should not only be the realm of child language researchers. The degree to which phonemic awareness plays a role in adult reading skill is woefully underexplored.

There are number of questions which our study seeks to answer:

- Do adults continue to be more syllabically aware than phonemically aware, or does phonemic awareness “catch up”?
- Are adults equally phonemically aware? Is the playing field level?
• Or, do adults, despite years of exposure to alphabetic print, continue to be differentiated on the basis of phonemic awareness tasks?
• Is either phonemic or syllabic awareness associated with reading ability in adults?

Research cited in section 3.1 suggests that syllables continue to be processed differently from segments throughout adulthood. Longitudinal studies on developing readers suggest that individual differences in literacy skills emerge early on and tend to persist over time (Lonigan, Burgess & Anthony, 2000). And, the work in the previous section indicates that the phonemic detail of words plays a crucial role in adult reading. Taken together, this suggest that a connection between phonemic awareness and reading ability in adults is likely.

So what? Why is this an interesting question? Word identification, lexical decision and eye movement studies indicate that adults pay attention to graphophonic detail when reading, but that doesn’t tell us how or why that attention detail manifests itself. If phonemic awareness and reading ability are associated in adults, that helps us understand how adults read (i.e., what skills and strategies are important in effective adult reading, especially of new or low frequency words). Moreover, if phonemic awareness is differentiated in adults, that indicates that there is no “ceiling” effect for phonemic awareness, and that perhaps these skills can continue to improve. This, in turn, has implications for first language reading improvement, second language reading instruction, etc.
4.0. THE STUDY

Though we know that literate adults are phonemically aware, we don’t know whether phonemic awareness levels in adults are differentiated and/or whether those skills are related to reading ability. Do adults, like children, benefit from finely honed phonemic awareness skills and do those skills make them strong and effective readers?

The study will test a three-part hypothesis with regard to adult phonemic awareness and reading ability:

1. Participants will perform better on measures of syllabic awareness than phonemic awareness,
2. Phonemic awareness (measured by segment-based tasks) will be associated with reading ability, and
3. Syllabic awareness (measured by syllable-based tasks) will not be associated with reading ability

The participants, literate university students, will be tested on a variety of syllabic and phonemic awareness tasks. Participants will be asked to perform three different tasks (a deletion task, a substitution task, and a reversal task) that require them to manipulate two different types of linguistic units (syllables and segments), for a total of six tasks in all., and then the results will be compared to their performance on two GRE tests: (1) a reading comprehension test and vocabulary test, and (2) a test of analytic ability. The former will be used to determine the participants’ reading ability (and the correlation between phonemic awareness and reading ability), whereas the latter is a control measure, administered to ensure that any correlations between phonemic awareness and
reading ability are not the result of mere cognitive ability, but rather some reading-
specific linguistic skill.

The structure of the phonemic awareness portion of the experiment is as follows.

This design is illustrated in the table below:

**Table 4.1: Experimental Design**

<table>
<thead>
<tr>
<th>Sound Awareness Tasks</th>
<th>Segment-based tasks</th>
<th>Syllable-based tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deletion</strong></td>
<td>Delete Segment Task (1)</td>
<td>Delete Syllable Task (2)</td>
</tr>
<tr>
<td><strong>Substitution</strong></td>
<td>Substitute Segment Task (3)</td>
<td>Substitute Syllable Task (4)</td>
</tr>
<tr>
<td><strong>Permutation</strong></td>
<td>Reverse Segment Task (5)</td>
<td>Reverse Syllable Task (6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test of Reading Comprehension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test of Analytical Ability</td>
</tr>
</tbody>
</table>

Examples of each of these tasks are given below, using the word *frantic* and some possible responses (the range of acceptable responses is included in appendices).

**Task One: Delete Segment Task**

Instructions: *What would the word ‘frantic’ sound like if the first sound were taken off?*
Response: /æntik/

**Task Two: Delete Syllable Task**

Instructions: *What would the word ‘frantic’ sound like if the first syllable were taken off?*
Response: /tik/

**Task Three: Substitute Segment Task**

Instructions: *What would the word ‘frantic’ sound like if the first sound were replaced by the first sound in ‘blasted’?*
Response: /bæntik/
Task Four: Substitute Syllable Task
Instructions: What would the word ‘frantic’ sound like if the first syllable were replaced by the first syllable in ‘blasted’?
Response: /blæstk/

Task Five: Reverse Segment Task
Instructions: What would the word ‘frantic’ sound like if the first sounds in the two syllables were reversed?
Response: /tænfolk/

Task Six: Reverse Syllable Task
Instructions: What would the word ‘frantic’ sound like if the two syllables were reversed?
Response: /tkfæn/

Previous studies on phonemic awareness have shown that tasks which require syllable manipulation are the easiest for participants to complete, whereas tasks which require segment manipulation are the most difficult to complete. Syllabic awareness tasks require only a low level of sound awareness, a level attested in preliterate children and illiterates. Segmentation tasks like those above (falling into Adams level five) require a sophisticated level of phonemic awareness that seems to require alphabetic experience. Therefore, it is predicted that within each task type, participants will perform best on syllable tasks and worst on segmentation tasks.

Because literate adults are known to pay attention to graphophonic information when reading (per the research cited in Chapter Three), it is further predicted that adults will be differentiated with regard to performance on the most difficult phonemic awareness tasks, and that performance on segment manipulation tasks (which tap into the most sophisticated phonemic awareness) will be a predictor of reading ability. Syllable
tasks will serve as a control; since syllables are a lower-level processing unit; they are not expected to be a predictor of reading ability.

4.0.1. Sound Awareness Tasks: A Natural Process?

The results of sound awareness studies are only interesting insofar as they reveal something about a subject’s natural language ability. Naturally occurring language games may also be used to argue that the tasks in this study test true natural language ability, versus quirky task-oriented skills. Naturally occurring language games (or “ludlings”\(^4\)) have played a role in the development of linguistic theory for over forty years. Chomsky & Halle cited Pig Latin data in *The Sound Pattern of English* in 1968; Bagemihl (1996) identifies this as the earliest contribution of language game data to phonological theory. Bagemhil notes that more recently, ludlings, which have been accepted as evidence for everything from the psychological reality of the syllable to evidence for templatic morphology to the suprasegmental status of tones.

The tasks in phonemic awareness experiments generally take the form of invented language games (invented by linguists, educators, psychologists, and speech pathologists for training and diagnostic purposes), but naturally occurring language games (invented by speakers for no greater reason than language play) take the same forms. Anderson (1992) argues that language games may actually tell us *more* about linguistic abilities than naturally occurring morphology:

> Some [morphological] rule types are unattested not because they are beyond the bounds of human linguistic capacity, but rather because there is not coherent sequence of possible historical change that would give rise...In the phenomenon of ‘secret languages’

---

4 A term coined by Laycock (1972), and used extensively by Bagemhil and others.
or ‘language games’ [there are] a wide range of process types which are not found in natural languages. Since they are not constrained by the limits on historical change, they are freer to exploit the limits of human linguistic capacities. (Anderson, p. 63).

Anderson’s point is that “natural” is not synonymous with “broadly occurring”; due to historical change or other factors, perfectly “natural” types of syllable and phoneme manipulations may become rare. There are certainly parallels with the phonemic inventory of a language; though /x/ is a perfectly “natural” sound, it is not present in modern-day English. Historical change may determine whether a given sound or phonological process is present in one language but absent in another.

Cross-linguistic evidence shows that tasks participants are asked to perform in this study are, in fact, natural (if not broadly occurring). Segment-based language games even exist in languages without alphabets: in Luganda (Kilbride & Kiblbride, 1974), a game requires that each syllable be followed by "z" and the previous vowel: omusajja > omuzusazajjaza. In a Bedouin Hijaze Arabic game (McCarthy, 1981) single consonants can be metathesized: kaatab > bataak; taakab > taabak. In Fanqie, a Mandarin language game (Yip, 1982), the syllable is split and infixed: ma > mayka; pen > pay-ken ‘book.’

Each of the tasks in this study occurs in some form in a naturally occurring language game. A version of segment deletion occurs in that old standby, Pig Latin, in which the player has to delete (extract) the initial segment and move it to the end of the word (game: /gem/ → /emge/). A similar game in Cuna, a Chibchan language of Panama, invokes syllable deletion: the first syllable of a word is stripped off and then moved to the end of the word (/uwaya/ → /wayau/) (Bagemihl, 1989). Phoneme substitution can
be seen in a Luganda game, in which each syllable beginning with a consonant is reduplicated, with /z/ in that consonant’s place (/omusajja/ → /o-mu-zu-sa-za-ja-za/) (Kilbride & Kilbride, 1972). **Syllable substitution** is attested in an informal language game played by my Swarthmore College peers, in which words ending in -ter had their final syllable supplanted by /tri/:  *water: /warət/ → /watri/, bitter: /btrət/ → /btri/.* Substitution games are further attested in examples of children’s spontaneous language play. Two examples that illustrate this are *deanut dutter dandwich* (“peanut butter sandwich”) as segment substitution (Kleeck & Bryant, 1984) and *Mommy, is it an a-dult or a nuh-dult?* as syllable substitution (Gleitman, Gleitman, & Shipley, 1972).

Even reversal tasks, which are less likely to occur as morphological processes, make their way into language games. Bagemihl cites Zande, a Niger-Congo/Adamawa-Ubangian language of Zaire, as an example of a language with a **syllable reversing** language game (/tikpo/ → /kpoti/), and Chasu as an example of a language with **segment reversing** games (/sano/ → /nasol/).

So, each of the tasks in the experiment is attested in a natural language process; the operations which participants are asked to perform all are found in naturally occurring language games. They also occur in spontaneous speech errors. Fromkin (1973) notes that, “by far the largest percentage of speech errors of all kinds show substitution, transposition (metathesis), omissions or addition of segments the size of a phone…both within words and across word boundaries.” Some examples of spontaneously occurring speech errors which correspond to the tasks in this study are: *week long race > reek long*
race (phoneme substitution), harp-si-chord > carp-si-hord phoneme reversal),
tremendously > tremenly (syllable deletion), and Moran and Fader > Morer and Fadan
(syllable reversal).

The fact that even the most difficult tasks below are attested in natural language
games should not be interpreted to mean that all human language speakers possess the
phonemic awareness necessary to play the games. On the contrary:

It appears that an alphabetic writing system may be a prerequisite for a segment
reversal ludling /language game/ to appear in a language...however, this is not a
sufficient criterion, since many languages with alphabetic systems have only
syllable reversing ludlings. Moreover, in languages with segment reversing
ludlings, the reversal is clearly not based on the orthographic representations, as
the English examples...illustrate....It seems that the presence of an alphabetic
writing system is necessary for the establishment of some metalinguistic
awareness of the notion of 'segment'; beyond this, however, the phonological
system takes over as the primary basis for reversal. (Bagemihl, 1989, p. 485)

Bagemhil’s observations about naturally occurring language games jive with what we
hope to demonstrate in an experimental setting: manipulation of syllables is more
common, and likely easier, than manipulation of segments. Citing language games to
justify task naturalness in no way implies that phonemic awareness is an easy or natural
task; it only confirms that the abilities to be tested in this study are within the realm of
human linguistic capacity.

4.1. **Pilot: Delete Segment Task**

A certain challenge lies in constructing tasks that determine the phonemic
awareness of adults, however, because all literate adults, by virtue of their alphabetic
literacy, are understood to be phonemically aware to a certain degree. Although it is
relatively easy to differentiate phonemic awareness abilities in children (i.e., Child A says
that *cat* has three sounds, whereas Child B says *cat* has one sound; therefore, Child A is phonemically aware and Child B is not), it is more difficult to distinguish levels of phonemic awareness in adults.

Recall the five levels of sound awareness proposed by Adams:

<table>
<thead>
<tr>
<th>Level</th>
<th>Abilities Associated with Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Appreciation of sound.</td>
</tr>
<tr>
<td>2</td>
<td>Sensitivity to similar or dissimilar phonemes.</td>
</tr>
<tr>
<td>3</td>
<td>Ability to blend and split rimes and onsets of syllables.</td>
</tr>
<tr>
<td>4</td>
<td>Ability to segment (count) phonemes.</td>
</tr>
<tr>
<td>5</td>
<td>Ability to manipulate (add, delete, move) phonemes.</td>
</tr>
</tbody>
</table>

Figure 4.1: Levels of Phonemic Awareness, per Adams (1990)

Because adults have had years of experience with language, tasks falling into the lowest levels of Adams' classification will be too compressed; all literate adults are able to contrast, blend and count the phonemes in simple words with relative ease. Therefore, the tasks most useful in the differentiating of adults will be phoneme manipulation tasks (which fall under the highest levels of sound awareness).

The tasks in this study are drawn from those used in previous phonemic awareness studies, most of which involve children. In each of the experiments with children, task performance was gauged by subject error rate on phonemic awareness tasks. Since adults have greater cognitive capabilities than children, and since moreover they have greater *linguistic* capabilities than children, the tasks used in experiments with
children are not challenging enough to adults to yield any interesting results. For instance, all literate adults can, with nearly 100% accuracy “count” the number of sounds in a word when there is a one-to-one correspondence between the number of phonemes and the number of graphemes; adults are helped in this task type by their orthographic knowledge and experience. However, the orthographic knowledge that adults possess might also be used as an impediment; that is, stimuli with a graphophonetic mismatch might be used to elicit higher error rates on adult phonemic awareness tasks. The pilot task described below tested this hypothesis.

A task used in many phonemic awareness studies with children is the Delete Segment Task (see Bradley and Bryant, 1983, among others). In this task, children are asked to delete the initial phoneme in a word. A pilot experiment was conducted to determine if adults do, in fact, exhibit varying performance on a phonemic awareness tasks. The goal of the experiment was to determine what type of stimuli might generate errors among adult participants.

**Participants**

Participants were thirteen University of Arizona undergraduates, all of whom were native speakers of English.

**Materials**

In segment deletion tests with children, the instructions often are something like, “Listen to the word task. If you take away the /t/ sound, what word is left?” (Stanovich
et. al., 1984; Cunningham, 1990) and the stimuli are such that when the first sound is stripped off, a real word of English remains (for example, *pink, told, man* → *ink, old, an*). The stimuli are words which begin with a consonant-vowel sequence, not a cluster. Literate adults generally find this task quite easy, especially since the real-word status of the correct response serves as a “check” to their answers. It was determined that replicating the Stanovich/Cunningham segment deletion task with adults would fail to elicit enough errors to differentiate adult phonemic awareness.

However, it was important to remain faithful to the original methodology, since the tasks in this study strive to draw the same kinds of conclusions about phonemic awareness and reading as experiments with children. The least drastic means of adapting the study to adults was to retain the original task and procedure while replacing the stimuli with much more challenging items.

The stimuli in the Cunningham and Stanovich experiments were monosyllabic words beginning with a CV sequence; in these stimuli the correct response was a common English word. In this pilot, the stimuli were bisyllabic words beginning with a variety of sequences (more below) which are nonwords when the first consonant is deleted.

Based on the studies on orthographic interference and phonological access cited in the previous chapter, it was determined that one way to make the stimuli more difficult was to include stimuli which lack a one-to-one relationship between the phonemes and graphemes of their initial segment (the segment to be deleted). Because aural stimuli
would call up “orthographically influenced phonological representations,” orthographic mismatches could be employed to make stimuli more challenging.

Each stimulus had a word-initial onset falling into one of four categories:

1. a single phoneme spelled with a single consonant, like baby /bebi/ (a one-to-one correspondence of phonemes and graphemes)
2. a single phoneme spelled with a digraph, like thesis /ðisis/ (a one-to-two correspondence of phonemes and graphemes)
3. a consonant cluster, spelled with a single grapheme, like music /mjuzɪk/ (a two-to-one correspondence of phonemes and graphemes)
4. a consonant cluster, spelled with more than one grapheme, like climax /klɛmæks/ (a two-to-two correspondence of phonemes and graphemes)

It should be the easiest for participants to delete an initial segment from a stimulus in category (1), since doing so does not require extraction of a phoneme from a cluster or involve a mismatch of phonological and orthographic representations. Conditions (2) and (3) involve an orthography/phonology mismatch, and should present participants with some difficulty if they are using orthographic representations in their task strategy (that is, they may give /hisɪs/ as a response to thesis in the segment deletion task, or /uzɪk/ as a response to music). Finally, conditions (3) and (4) should be difficult because they begin with clusters, so segment deletion requires participants to extract the initial segment from the rest of the onset.

The test items and correct responses are listed in Appendix A.

Procedure
The instruction to participants was, “I’m going to give you a word, and I want you to tell me what that word would sound like if the first sound were taken off.” They then heard the task modeled on ten practice items, which were followed by thirty test items. Participants heard instructions through a set of headphones and spoke responses into a hand-held microphone connected to a tape recorder.

Results

The mean correct response rates for each of the four conditions are presented in Table 4.2:

Table 4.2: Performance (% correct) on the Delete Segment Task (by subjects)

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SE</th>
<th>95% Confidence Interval for Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>One-to-One</td>
<td>13</td>
<td>95.80%</td>
<td>7.97%</td>
<td>0.02</td>
<td>0.91</td>
</tr>
<tr>
<td>One-to-Two</td>
<td>13</td>
<td>85.71%</td>
<td>19.34%</td>
<td>0.05</td>
<td>0.74</td>
</tr>
<tr>
<td>Two-to-One</td>
<td>13</td>
<td>76.92%</td>
<td>31.70%</td>
<td>0.09</td>
<td>0.58</td>
</tr>
<tr>
<td>Two-to-Two</td>
<td>13</td>
<td>35.38%</td>
<td>35.73%</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>73.46%</td>
<td>34.32%</td>
<td>0.05</td>
<td>0.64</td>
</tr>
</tbody>
</table>
In Figure 4.2, the correct response rate by percentage is presented in graphical format:

![Performance on the Delete Segment Task (by subjects)](image)

**Figure 4.2: Performance on the Delete Segment Task (by subjects)**

A one-way analysis of variance was used to test for differences among the four conditions; Subject performance on the four conditions differed significantly across conditions, $F(3, 48) = 13.47, p < .001$. Post hoc comparisons of the four conditions using the Tukey HSD test revealed that performance on the two-to-two condition was significantly worse than on both the one-to-one and one-to-two conditions, both at the $p < .001$ level. The two-to-two condition also was significantly worse than the two-to-one condition, $p = .001$. Differences among the other three groups were not statistically significant at $p < .05$.

A by-item analysis largely coalesced with the by-subject findings. There was a significant difference across conditions, $F(3, 26) = 37.39, p < .001$. Post hoc
comparisons of the four conditions using the Tukey HSD test revealed that performance on the two-to-two condition was significantly worse than on all three conditions at the \( p < .001 \) level. Additionally, in the items analyses, performance on the two-to-one condition was also significantly worse than on the one-to-one condition, \( p = .006 \).

**Discussion**

Taken together, these results suggest that onset type has an effect on participants’ ability to delete an initial segment. Subject error rates were highest on conditions 3 (two-to-one) and 4 (two-to-two), the conditions in which participants are asked to extract an initial segment from a cluster. Performance on the two-to-two condition (*climax*) was significantly worse than all other conditions in both a by-subjects and by-items analysis, and the two-to-one condition (*music*) was significantly worse than the one-to-one condition (*baby*) in a by-items analysis. The two “cluster” conditions require a more sophisticated level of phonemic awareness than extraction of an onset from its rime (as required in conditions 1 and 2). This finding is consistent with Adams’ levels of sound awareness, in that onset/rime knowledge is at a lower level of sound awareness than segment manipulation.

As expected, participants were not challenged by the 1-to-1 *‘baby’* condition (one phoneme represented by one grapheme), successfully deleting an initial phoneme nearly 96% of the time. In this condition, neither phonological complexity nor orthographic interference is at play; participants do not have to extract a single phoneme from a complex onset nor have to wrestle with a mismatch between the phonological and
orthographic representation of the onset. In both the by-subjects and by-items analysis, participants found it easier to delete an initial constant in a word with a orthographic cluster/digraph (e.g., thesis) than in a word with a phonological cluster (e.g., scarcely). Furthermore, in both analyses, there was no difference between the digraph (1-to-2) condition (thesis) and the 1-to-1 condition (baby); orthographic complexity did not appear to make the task more difficult.

Based on the results of the pilot, a decision was made to include only stimuli with clusters (phonological complexity) in the main study.

4.2. Preliminaries

In section 4.3, the six tests of sound awareness are presented in detail. In this section, some general matters relating to stimuli coding (i.e., the definition of “syllable” and “segment”) and task design are discussed.

4.2.1 Segment and Syllable Preliminaries

Because the experiment requires participants to perform six syllable and segment manipulation tasks, it is important to define what characterizes a syllable and a segment in English. For purposes of correct and consistent coding of participants’ responses to phonological tasks, the phonological units involved must be clearly defined.

4.2.1.1. Syllables

Even though the basis of phonemic awareness research is that syllabic awareness requires a lower level of sound awareness than phonemic awareness, it is often easier to define what comprises a segment in English than what comprises a syllable. Since
phonemic awareness research on children has traditionally employed stimuli that are monosyllabic or disyllabic and bimorphemic, it is of little help in determining what defines a syllable for the purposes of the experiment here.

It is widely accepted that the syllable is a bona fide phonological unit (Anderson, 1969; Fudge, 1969; Kahn, 1976; Blevins, 2004). Some (Steriade, 1999) have argued an alternate position, suggesting that syllables are not legitimate phonological units, and that seemingly syllable-based phenomena are the result of segmental and word-edge phonotactics. Nevertheless, there are syllable-based writing systems, syllable-based language games, and phonological rules which depend on syllable boundaries. But, even for those who accept the phonological existence of the syllable, though, the composition of a given syllable is not always clear.

Syllables in English are often ambiguous, and so, in the syllable-based tasks in this experiment, participants may exhibit variance in their responses to syllable-based tasks, variance which is – on the basis of syllable theory – legitimate. Classic theories of syllabification produce conflicting interpretations of English syllables. Consider the possible syllabifications of *fresco* and *baby* in the table below:

**Table 4.4: Alternate Theories of Syllabification**

<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>Maximize Onset</th>
<th>Sonority Dispersion</th>
<th>Ambisyllabicity</th>
<th>Minimally Bimoraic</th>
</tr>
</thead>
<tbody>
<tr>
<td>baby</td>
<td>/b.e.bi/</td>
<td>/b.e.bi/</td>
<td>/b.e.bi/</td>
<td>/b.e.bi/</td>
</tr>
</tbody>
</table>
The Maximal Onset Principle (MOP) (Pulgram, 1970) posits that when the consonants in a word can be syllabified in more than one way, the preferred syllabification is that which places as many consonants as possible in the onset. Following the MOP, then, the syllabification of the word *fresco* is *fre.sco*. The Sonority Dispersion Principle (SDP) (Clements, 1988), however, says that the correct syllabification of a word results from maximizing sonority dispersion in the onset and minimizing it in the coda. According to this theory, then, the correct syllabification of *fresco* is *fres.co*. Kahn (1976) was among the first to propose that the syllabification of a word like *fresco* might be more complicated; Kahn’s theory contends that in *fresco*, in which the first syllable is stressed, the /s/ sound is ambisyllabic - a resident of both syllables (*fres.sco*). Hammond (1999) proposes an Optimality-Theoretic analysis of English stress, and attributes the affinity medial consonants have for short vowels to a foot-based weighting rule in English. In this constraint, unreduced syllables are minimally bimoraic, which can satisfied by resyllabifying a consonant from the right, resulting in a syllabification of *bulky* as *bulk.y*. The theories do not concur with regard to coding of answers in a syllable based task.

Phonotactic legality does seem to be a clear consideration in syllabification. Treiman and Zukowski (1990) conducted a series of experiments to determine what effect phonotactics, stress, vowel length, the MOP and sonority have on the syllabification of medial clusters. Legality was by far the most important factor; participants syllabified words like *atlases* and *confetti* (in which the medial consonant
cluster would be illegal both at the beginning and the end of a word) between the two consonants (at.lases and con.fetti) between 99% and 100% of the time.

Other factors affecting syllabification are not so definitive. In a large-scale study involving 4900 syllabifications of bisyllabic English words, Eddington, et. al. (2013) found support for the importance of legality but otherwise found a great deal of variation among subjects. Overall, they found 80% or higher agreement on the syllabification of only 63% of items studied (notably, subjects were not allowed to select a syllabification involving ambisyllabicity). These high-agreement items comprised only half of the items with a single medial consonant (like baby) and only 80% of the items with two medial consonants (like fresco).

Syllabification studies have uncovered a number of factors which consistently and significantly affect syllabification in English. Generally speaking, in the syllabification of medial consonants in bisyllabic words, syllables with stressed vowels attract consonants to both their onset and coda) (Derwing, 1992; Treiman & Zukowski, 1990) and syllables with lax vowels attract consonants to their codas (Hammond 1997). Additionally, sonorous medial consonants are more likely to be attracted to the coda of the first syllable than are obstruents (Derwing & Neary, 1991; Zamuner & Ohala, 1999).

However, despite these findings, Treiman & Zukowski (1990), Treiman & Danis (1988), and Meador & Ohala (1993) all found support for ambisyllabicity in syllabification tasks. If ambisyllabicity exists in English syllables, it is difficult to justify one correct syllabification for fresco and baby. In fresco, the first syllable is stressed and contains a lax vowel that would seem to suggest the fres.co syllabification. Still, Treiman
and Zukowski found that \textit{fres.co} and \textit{fres.sco} syllabifications were possible (9\% and 43\% of the time, respectively). In the case of \textit{baby}, the first vowel is tense, suggesting the syllabification \textit{ba.by}. However, Meador and Ohala found that these cases were syllabified \textit{bab.by} over 20\% of the time.

The relevance of these findings to the study is as follows: since the syllable-based tasks require participants to delete/substitute/reverse syllables, whether or not a medial consonant is ambisyllabic determines whether a subject’s response should be deemed correct. Consider the case of the Delete Syllable Task, in which participants are asked to strip off the first syllable of a word. The instructions to participants in this task are, “I’m going to give you a word, and I want you to tell me what that word would be if the first syllable were taken off.” If responses that violate phonotactic rules of English are marked as incorrect, there are still several possible responses to the question, “What does X sound like when the first syllable is removed?” With so much evidence for variability among English speakers’ syllabifications, it is difficult to justify one definitive pronunciation.

A second consideration supports a more liberal coding of syllable responses in the Delete Syllable Task. It is not clear (and the experiment design does not dictate) the strategy participants might use in crafting their responses. In cases of ambisyllabicity, it is possible that these instructions could elicit two different responses. Let’s say two participants hear the word \textit{baby} and judge the medial consonant to be ambisyllabic. When prompted for a response, Subject 1 might view the task as identifying the first syllable /beb/ and spitting out the remainder /i/ (Treiman and Danis found that
participants tended to “force” singly spelled consonants into one syllable or another, even in the most stereotypically ambisyllabic environments). Subject 2, on the other hand, might view the task not as stripping off the first syllable, but identifying the second, and so would say /bi/.

For these reasons, in the syllable-based tasks, all responses which conform to ambisyllabic or otherwise possible conceptions of the syllable will be coded as correct (as long as they do not violate rules of phonotactics). Coding of responses are listed in appendices, referenced in the writeup of each task.

### 4.2.1.2. Segments

Although the segment in English is less ambiguous than the syllable, there are a few issues which must be addressed, specifically the status of /sl/ clusters (as in sticky), /Cj/ clusters (as in cute) and /Cw/ clusters (as in quick).

S-clusters in English are unquestionably exceptional; there is strong and consistent evidence that they needed to be handled differently than other clusters in English. First, they violate the sonority hierarchy, which states that onsets must rise in sonority and codas must fall in sonority (the segment /s/ is more sonorous than /t/, and yet is further removed from the syllable nucleus in sticky). Second, in the language acquisition of both typical children and in children with phonological disorders, /sl/-clusters are acquired at different rates than similarly-structured consonant clusters (Yavaş & McLeod, 2010).
The /s/ in clusters has been classified by some as extrasyllabic (Clements and Keyser; 1983). Selkirk (1982) proposed a different explanation for the anomalous behavior of s-clusters, positing that s-clusters at the beginnings of words are actually complex segments. Treiman et. al. (1992) found that English-speaking participants treated s-clusters differently from other clusters in a syllabification experiment; when asked to syllabify two-syllable nonwords with second-syllable stress, they often broke up word-medial s-clusters but not word-medial non-s-clusters; they conclude from this finding that /s/ is not a legal English onset when part of a cluster.

The classification of s-clusters affects coding of participants’ responses throughout the experiment. For instance, if asked to delete the first phoneme in a word with an s-cluster, participants may be treat s-clusters differently from other clusters, regardless of whether they are extrasyllabic, part of a complex segment or part of an illegal onset. Consider the following chart:
Table 4.5: Treatment of /s/ clusters

<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>Response to Delete Segment Task, if /s/ is part of an ordinary cluster</th>
<th>Response to Delete Segment Task, if /s/ is extrasyllabic, part of a complex segment, or part of an illegal onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>sticky</td>
<td>tiki</td>
<td>iki</td>
</tr>
<tr>
<td>species</td>
<td>pisiz</td>
<td>isiz</td>
</tr>
</tbody>
</table>

Giving the overwhelming evidence that /s/ does not behave like other phonemes in consonant clusters, the decision was made to code responses that suggested an extrasyllabic/complex/illegal onset interpretation of /s/ as correct.

Clusters with /w/ or /j/ as the second consonant are also tricky. Are the /j/ and /w/ in these cases really the second consonants of consonant clusters, or rather on-glides to the following vowel? Davis and Hammond (1994) argue that /w/ and /j/ should be treated differently from each other, with /w/ as part of the onset (that is, the second consonant of a consonant cluster in the cases cited here), but /j/ is co-moraic with the following vowel, and thus part of the coda. They cite the following evidence for their claim:

- Cw has far fewer phonotactic constraints on it: Cw occurs before all vowels but /u/, /aw/, and /oy/, whereas /Cj/ occurs only before /u/ only (indicating that j+u sequences are in actuality a diphthong, /iu/)

- In the language game Pig Latin, /CwV/ is unambiguously treated as part of the onset (for example, /unswe/ is always the response to “swoon”), while /CjV/ sequences are subject to variation in which some respondents treat it as part of the vowel (so, “cute” might yield either /jutke/ or /utke/), and

- In the “Name Game,” the /w/ is deleted in /Cw/ names like “Gwen” (gwen, gwɛn, bo bɛn, benæn fænə fo fən...), but the /j/ is sometimes retained (that is, treated
like part of the vowel) in /Cj/ names like “Beulah” (bjulə, bjulə, bo bjulə, benænə fænə fo fjulə...).

Thus, there are many reasons for questions whether the /Cj/ words in this experiment are not truly words that begin with consonant clusters. However, Davis & Hammond’s evidence from Pig Latin and the “Name Game” is not without variation; there are dialects of each game in which the /j/ of /Cj/ sequences is treated as part of the onset.  

Secondly, the pilot experiment provides evidence that participants treated /Cj/ sequences as clusters, rather than as consonant + onglide sequences. In the experiment, participants were asked to delete the initial phoneme of the word, and they treated words beginning with /Cj/ sequences differently than words beginning with a single consonant. In words which began with a single consonant (e.g., pony), participants gave a correct response (e.g. /oni/) 96% of the time. In words which began with a /Cj/ sequence (e.g., puny), participants gave a response consistent with the onglide interpretation (e.g., /juni/) 77% of the time. In an items analysis, performance was significantly worse in the /Cj/ condition (M = .77, SD = .32) than in the /C/ condition (M = .96, SD = .08), t (12) = 2.67, p = .02, indicating that participants found /Cj/ cases more difficult, and that, in turn, the /y/ in /Cj/ words is not an indisputable part of the vowel.

So, for the purposes of this study, all clusters (/Cj/, /Cw/, and /CC/) will be treated in the same fashion, as sequences of two consonants.  

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5 Davis and Hammond, in citing the Pig Latin response of [utke] for “cute,” suggest that “while the /j/ in the CjV sequences is not part of the onset, it does move into the onset by a later rule” (p. 167).

6 The consequences of this coding decision are ultimately minimal. [Cj] stimuli were only included in the Delete Segment Task, not in the Reverse Segment Task or the Substitute Segment Task. Overall, only 6 of 72 segment test items included [Cj] stimuli.
4.2.2 Task Preliminaries

Since the experiment participants are adults, it was determined that the tasks had to be made more difficult than parallel tasks which have been performed on children, while remaining true to the original methodologies. As such, the stimuli, instructions and response time were all slightly adapted.

The stimuli in the adult experiment were made considerably more difficult. First, all correct responses were nonwords (as opposed to the children’s experiments, in which all correct responses were words). Secondly, based on the results of a pilot, all test items in this experiment began with consonant clusters. The instructions to the participants were similar to those given children, except that the real word vs. nonword status of the responses was not made explicit (that is, children were told that the correct response would be a real word of English). Finally, the adult participants were given a limited amount of time in which to respond to a stimulus, unlike previous studies with children.

All of these changes were instituted to make the experiment more challenging to adults, with the goal of eliciting higher error rates.

The six tasks below have the advantage of clinical control; the task instructions, task familiarity, learning period, and stimulus pattern are the same in each. Because of this control, the data from different tasks can be compared with each other and to the parallel measure of reading ability without concern that the results are confounded by some task-specific factor.7

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7 Still, as Mann suggests, it would be intriguing to study data from naturally occurring language games: “One would like to see research that investigates the phoneme awareness of children and adults
4.3. Participants

Forty-two University of Arizona students participated in the experiment in exchange for extra credit in a class. Nine students were excluded from the study. Of these, one was not a native or near-native speaker of English\(^8\), one did not complete the oral part of the experiment, and one failed to follow task directions. Additionally, six participants were unable to complete portions of the experiment due to equipment malfunction. Excluding these, the subject pool consisted of thirty-three participants who were unaware of the purpose of the experiment.

For purposes of list-balancing (discussed in more detail below), participants were arbitrarily divided into two groups, henceforth referred to as Group A and Group B. There were 18 participants in Group A and 15 in Group B. In all analyses, all 33 responses were aggregated.

4.4. Materials

There were two sets of materials employed in the experiment: aural materials used to test participants’ ability to manipulate syllables and segments, and written materials used to test participants’ reading and analytical skills.

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\(^8\) Subjects who learned English while preliterate (for purposes of this experiment, before the age of three) were included.
4.4.1. Sound Awareness Tasks Materials

Each subject was presented stimuli from one of two lists; Group A participants heard List 1 stimuli and Group B participants heard List 2 stimuli. Subjects who received List 1 stimuli on a segment-based task received List 2 stimuli on the paired syllable-based task, and vice-versa. The stimuli on the two lists were matched for frequency using PHONDIC, a file of 20,000+ English words (www.lexicon.arizona.edu/~hammond/newdic.html) and phonological pattern. This list-balancing was incorporated into the design so that any conclusions drawn from a comparison of sister experiments (that is, segment and syllable manipulations of the same task type) was sure to be the result of differences in sound awareness rather than differences in the features of the stimuli.

The stimuli shared the following characteristics:

- All test items were two syllable words in which the second syllable contained an unreduced, stressless vowel;
- All test items began with what could be characterized as a CCV sequence, which was either
  - a /Cj/ word (i.e., /bjurί/)
  - a /Cw/ word (i.e., /kwazi/), or
  - a “straight” cluster (i.e., /fɪɛsko/)

These three types of initial clusters were chosen based on the results of the Delete Segment Pilot. The stimuli and practice items for each task are listed in Appendices B, C and D.
4.4.2. Reading and Analytical Task Materials

In addition to the six sound awareness tasks, all participants were administered written tests of reading and analytical ability. These tests were compiled from tests previously used in General Record Exams (GREs). The tests consisted of 37 multiple choice questions.

Twenty-seven of the questions were drawn from the exam’s verbal ability section, consisting of both vocabulary and reading comprehension questions. This test was deemed appropriate for adults because of its similarity to the tests of reading ability often used in tests of the relationship between phonemic awareness and reading ability in children. Although the Peabody Picture Vocabulary Test - Revised (PPVT-R) is a popular test with very young participants (Ball & Blachman, 1991; Bowey & Francis, 1991), Metropolitan Achievement Tests are frequently used with older children (as seen in Stanovich, Cunningham & Cramer, 1984; Cunningham, 1990; Hatcher et. al., 1994; Mann, 1993). The Metropolitan Tests, Primer and Primary levels, are used to “measure sound-symbol correspondence, word recognition, and reading comprehension” (Cunningham, 1990, p. 432). Obviously, the written test administered in this experiment does not offer a direct test of sound-symbol correspondence, but since the participants in this experiment are literate adults rather than preliterate children, this is an expected (and ultimately irrelevant) difference.

The remaining ten (of 37) questions on the written test were drawn from the exam’s analytical ability section, and served as a control: it was not expected that there would be any correlation at all with participants’ performance on phonemic awareness
tasks, as no correlations were found in control test with children. Control tests which have been used in phonemic awareness experiments with children include IQ tests (Stanovich, et. al., 1984), music segmentation tests (Morais, et. al, 1986), and nonphonological linguistic tests (i.e., syntax tests) (Lundberg, 1991). If, in fact, a correlation was found between the analytical questions and phonemic awareness ability, it would indicate that participants’ performance on phonemic awareness tasks was based more on analytical strategy than linguistic skill.

4.5. Procedure

4.5.1. Sound Awareness Task Procedure

Participants were played recorded instructions through headphones. All heard the following introductory instructions:

We’re going to play some games with words. In each game, you will be given a set of instructions and some examples showing how the game is played. You will have a limited amount of time to respond to each item, and there is no stopping or going back. There are six games in all.

Each task was preceded by task-specific instructions, listed in Table 4.3 below. For each task, participants heard five practice items, followed by the correct responses to those items. Upon completion of the practice items participants heard the prompt, “Now you try,” which was followed by twelve test items. The test items were presented approximately four seconds apart; timing of stimuli was controlled by an electric metronome. Each participant responded into a microphone, which was either hand-held or placed on a desk (participant’s choice).
<table>
<thead>
<tr>
<th>Task</th>
<th>Instructions and Sample Practice Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delete Segment Task</td>
<td>I’m going to give you a word, and I want you to tell me what that word would be if the first sound were taken off.</td>
</tr>
<tr>
<td></td>
<td>- Practice Item: <em>What would the word ‘frantic’ sound like if the first sound were taken off?</em></td>
</tr>
<tr>
<td></td>
<td>- Modeled Response: /æntik/</td>
</tr>
<tr>
<td>Delete Syllable Task</td>
<td>I’m going to give you a word, and I want you to tell me what that word would be if the first sound were taken off.</td>
</tr>
<tr>
<td></td>
<td>- Practice Item: <em>What would the word ‘frantic’ sound like if the first syllable were taken off?</em></td>
</tr>
<tr>
<td></td>
<td>- Modeled Response: /tik/</td>
</tr>
<tr>
<td>Substitute Segment Task</td>
<td>I’m going to give you two words, and I want you to tell me what would happen if you replaced the first sound in the first word with the first sound in the second word.</td>
</tr>
<tr>
<td></td>
<td>- Practice Item: <em>What would happen if you replaced the first sound in ‘brisket’ with the first sound in ‘fluster ’?</em></td>
</tr>
<tr>
<td></td>
<td>- Modeled Response: /frsket/</td>
</tr>
<tr>
<td>Substitute Syllable Task</td>
<td>I’m going to give you two words, and I want you to tell me what would happen if you replaced the first syllable in the first word with the first syllable in the second word.</td>
</tr>
<tr>
<td></td>
<td>- Practice Item: *What would happen if you replaced the first syllable in ‘brisket’ with the first syllable in ‘fluster ’?</td>
</tr>
<tr>
<td></td>
<td>- Modeled Response: /flasket/</td>
</tr>
<tr>
<td>Reverse Segment Task</td>
<td>I’m going to give you a word, and I want you to tell me what that word would be if the first sounds in each syllable were reversed.</td>
</tr>
<tr>
<td></td>
<td>- Practice Item: <em>What would the word ‘baptize’ sound like if the first sounds in the two syllables were reversed?</em></td>
</tr>
</tbody>
</table>
Reverse Syllable Task  

I’m going to give you a word, and I want you to tell me what that word would be if the two syllables were reversed.

- Practice Item: What would the word ‘baptize’ sound like if the two syllables were reversed?
- Modeled Response: /tæzbæp/

Some notes on procedures for each task: the Delete Segment and Delete Syllable Tasks are classic sound awareness tests which have been employed routinely in testing children (Bryant, et. al., 1990; Bradley and Bryant, 1983; Cunningham, 1990; Lundberg, et. al., 1988; Mann, 1986; Stanovich, et. al., 1984; Tornéus, 1984; among others). In the case of the Delete Segment Task, the practice items modeled the task with both /CV.../ words and /CCV.../ words, so that there would be no confusion about the unit participants were being asked to delete. After hearing both /bebi...ebi/ and /tribjut...ribjut/ modeled, participants knew that they were to perform a delete segment task, and not a delete onset task. In delete segment tasks with young children, both the stimulus and response are generally real words (e.g., /bæt/.../æt/). In order to make the adult task more difficult, responses to our task yielded nonwords.

The Substitution Tasks have been used in tests with children; an example of the instruction in a children’s substitution task is the following: “If I say the word go and then change the first sound by changing it to /n/, the new word will be no” (Stanovich, et. al., 1984; Treiman, 1985). The methodology here was adapted for two reasons. First, the
task had to be made more challenging for adults. Second, it was deemed preferable to avoid pronouncing the substituted segment in isolation as (1) the taped stimuli would make potentially make perception of isolated segments difficult, and (2) using the consonant + schwa pronunciation (i.e. /də/ for /d/) - a syllabic pronunciation) would cloud the distinction between the Delete Segment and Delete Syllable Tasks.

To avoid these issues, the instructions to participants for the Delete Segment task (noted in the table above) were as follows: “I’m going to give you two words, and I want you to tell me what would happen if you replaced the first sound in the first word with the first sound in the second word.” Following these instructions, the expected response to the stimulus pair *brisket/fluster* is */frisket/*. By altering the instructions in this way, the task was made more difficult (i.e., participants were not “given” the substituted phoneme, but had to isolate it themselves) while avoiding confusion about the unit of manipulation (there is nothing to indicate that the unit to be substituted is the minimal syllable */ka*/).

The Reverse Segment Task is the one measure of phonemic awareness in this experiment that has *not* been used in tests with children. Segment Reversal is a difficult task, requiring a phonological sophistication that preliterate and newly literate children simply do not have. The methodology is thus based on syllable reversal tasks with children (see below), with the only difference being that the unit of manipulation is the segment. The Reverse Syllable Task was modeled after Treiman & Danis (1988), who used it to test the syllabification of intervocalic consonants. They told their participants, “We’re going to play a game with words. I’ll show you how it goes by giving you some
examples. When I say *grandfather*, you say *father...grand*. When I say *catfood*, you say *food..cat*” and then gave them bisyllabic (noncompound, one-morpheme) words as stimuli.

4.5.2. Reading and Analytical Task Procedure

The written tests of reading and analytical ability were administered upon completion of the sound awareness tasks. Participants were not informed as to the origin of the questions they received. They had 30 minutes to complete the multiple choice test. All participants were given the same questions, in the same order.

4.6. Results and Discussion

4.6.1. Results and Discussion: Segments vs. Syllables

The results of all sound awareness tasks were coded as correct or incorrect. Acceptable correct responses for all tasks are listed in Appendices E through J. Coding of responses in all tasks was based on assumptions about extrametricality and ambisyllabicity discussed earlier in this chapter.

It should be noted that some items have more than one correct response because of the effect of ambisyllabicity. Consider the Substitute Syllable Task, using the *blanket/crumple* stimulus. Participants were asked to replace the first syllable of *blanket* with the first syllable in *crumple*. These words yield multiple syllabification possibilities. Both words have stressed, short vowels in their first syllables, which may create an ambisyllabic environment for the second consonant in the medial cluster. So, although
the preferred syllabifications for blanket and crumple are blan.ket and crum.ple (in which the word is split between the consonants in the cluster), blank.ket and crump.ple are also possible. Thus, responses to the Substitute Syllable Task for this item could be /krãmkowl/, /krãmpkowl/, /krãmpɔtl/, and /krãmɔtl/.

Even though all of these responses would have marked correct, the latter two never presented themselves.)

In the appendices, stimuli marked above with an asterisk (*) contain a medial cluster that could be syllabified in more than one way. Though it was expected that participants would place a syllable break in between the two consonants of the stimulus (since Treiman and Zukowski found participants preferred this syllabification over 90% of the time), responses that indicated a different syllabification were also marked correct. Since the word cyclone, for example, could be syllabified as cyc.lone or cy.clone, both /lɔykson/ and /kɔyslon/ are possible right answers in the Reverse Segment Task. With some stimuli, like vibrate, the alternate syllabification (vi.brate, instead of vib.rate) produces a phonotactically illegal, but not unpronounceable, response to the Reverse Segment Task. For instance, the syllabification vi.brate yields the response /brɔyveyt/ to this task. This is a pronounceable and legal string of letters in English on the surface, but if participants are performing the task correctly, the syllabification of this string should be /bɔy.veyt/, which has an illegal cluster as the onset to its second syllable. As it happens, no subject ever gave a response to the Reverse Segment Task that indicated a CV.CCVC

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9 These last two are based on the assumption that when subjects delete the initial syllable of blanket prior to substitution, they delete the ambisyllabic consonant along with it, leaving only [ɔt].
syllabification, even when the resulting onset cluster was perfectly legal. Thus, the only relevant correct responses are those listed in the appendix.

It was predicted that participants would perform better on syllable-based tasks than segment-based tasks, because syllables tap into a lower level of sound awareness than segments. Table 4.7 contains the mean correct response rates (and standard deviations) for each task type by unit:

<table>
<thead>
<tr>
<th>Task Type</th>
<th>Unit</th>
<th>Mean (out of 12)</th>
<th>% Correct</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deletion</td>
<td>Segment</td>
<td>9.27</td>
<td>77%</td>
<td>2.2</td>
</tr>
<tr>
<td></td>
<td>Syllable</td>
<td>10.24</td>
<td>85%</td>
<td>2.81</td>
</tr>
<tr>
<td>Substitution</td>
<td>Segment</td>
<td>2.39</td>
<td>20%</td>
<td>2.29</td>
</tr>
<tr>
<td></td>
<td>Syllable</td>
<td>6.61</td>
<td>55%</td>
<td>4.01</td>
</tr>
<tr>
<td>Reversal</td>
<td>Segment</td>
<td>2.36</td>
<td>20%</td>
<td>2.62</td>
</tr>
<tr>
<td></td>
<td>Syllable</td>
<td>10.45</td>
<td>87%</td>
<td>1.56</td>
</tr>
</tbody>
</table>

And figure 4.3 provides a graphical representation of subject performance on paired “sister” tasks:
Figure 4.3: Pairwise comparison of “sister” tasks

It appears that the segment-based tasks were more difficult than the syllable-based tasks across the board. In order to test the significance of these results, participants’ performance on the phonemic awareness tasks was subjected to a two-way analysis of variance involving three types of task (deletion, reversal and substitution) and two types of unit (segment and syllable).

Table 4.8 summarizes the results of the 3x2 ANOVA:

<table>
<thead>
<tr>
<th>Table 4.8: Task Type x Unit Factorial Analysis of Variance (By-Subjects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Type (Deletion, Substitution, Reversal)</td>
</tr>
<tr>
<td>Unit (Segment or Syllable)</td>
</tr>
<tr>
<td>Task Type x Unit (interaction)</td>
</tr>
<tr>
<td>Error (within groups)</td>
</tr>
</tbody>
</table>
All effects in both the subjects and items analysis were statistically significant at the $p < .001$ level. In the by-subjects analysis, there was a main effect for unit type, $F(1, 64) = 95.30$, $p < .001$, indicating that on the whole syllable-based tasks ($M = 4.68$, $SD = 4.03$) were significantly easier than segment-based tasks ($M = 9.10$, $SD = 3.43$). The same findings for unit type were found in the by-items analysis ($F(1, 23) = 76.95$, $p < .001$); syllable-based tasks ($M=76.51\%$, $SD = .21$) were significantly easier than segment-based tasks ($M=38.95\%$, $SD = .32$).

Post-hoc pairwise comparisons of unit (segment vs. syllable) manipulation per task type are presented in Table 4.9:
Table 4.9: Pairwise comparisons of Syllable vs. Segment Tasks (by subjects)

<table>
<thead>
<tr>
<th>Task Comparison</th>
<th>Mean Difference</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delete Syllable vs. Delete Segment</td>
<td>.97</td>
<td>3.03</td>
<td>1.84</td>
<td>32</td>
<td>.075</td>
</tr>
<tr>
<td>Substitute Syllable vs. Substitute Segment</td>
<td>4.21</td>
<td>4.23</td>
<td>5.72</td>
<td>32</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Reverse Syllable vs. Reverse Segment</td>
<td>8.09</td>
<td>2.72</td>
<td>17.09</td>
<td>32</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

The poc-hoc t-tests demonstrate that in addition to the overall effect for unit type, syllables were easier to manipulate than segments in the paired sister tasks for the substitution and reversal tasks. In the by-subjects analysis, participants found it significantly easier (at the p < .001 level) to manipulate syllables than segments (for substitution, t (32) = 5.72; for reversal, t (32) = 17.1). The findings from by-items analysis parallel the by-subjects findings; differences in the processing of syllables and segments was significant at the p < .001 level for the substitution and reversal tasks.

In the case of the deletion task, the difference was not significant in either the by-subjects or by-items analysis, though in both cases the p-value was less than .10 (by-subjects: t (32) = 1.84, p = .075; by-items: t (23) = 1.74, p = .096).

The data were analyzed with regard to performance on task type (deletion tasks vs. substitution tasks vs. reversal tasks). The results are presented in Table 4.10:
Table 4.10: Performance by Task Type (by subjects)

<table>
<thead>
<tr>
<th>Task</th>
<th>Mean (of 12)</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deletion</td>
<td>9.76</td>
<td>.31</td>
<td>9.14 - 10.38</td>
</tr>
<tr>
<td>Substitution</td>
<td>6.41</td>
<td>.27</td>
<td>5.88 - 6.94</td>
</tr>
<tr>
<td>Reversal</td>
<td>4.50</td>
<td>.40</td>
<td>3.7 - 5.30</td>
</tr>
</tbody>
</table>

In the by-subjects analysis, there was a main effect of task type, $F(2,128) = 81.35, p < .001$. The same effect was discovered in the by-items analysis, $(F(2,92) = 801.86, p < .001)$. Post-hoc t-tests confirm that, in both the by-subjects and by-items analyses, each task type differed from the other two task types at the $p < .001$ level, indicating that deletion, substitution and reversal varied in terms of difficulty, with deletion being the easiest task and reversal the most difficult.

Finally, the interaction effect was also significant, in both the by-subject and by-items analyses (by-subjects: $F(2,128) = 36.5, p < .001$; by-items: $F(2,128) = 351.96, p < .001$). This indicates that the segment vs. syllable effect was greater in the more difficult task types. This interaction may help explain the lack of a significant difference between syllables and segments in the deletion tasks. Participants, on the whole, found the Delete Syllable and Delete Segment Tasks fairly easy, scoring correct response rates of 85.33% and 77.25%, respectively. Because the deletion task itself was not difficult, it did not highlight the differing ways in which participants process syllables vs. segments, as did the substitution and reversal tasks.
**Discussion**

In sum, the results of the six phonemic awareness tasks confirm that adults find syllables significantly easier to manipulate than segments. This was the expected result, as syllabic awareness is a foundational, lower-level sound awareness skill and segmental (phonemic) awareness is learned via alphabetic experience. Even though alphabetic literates are phonemically aware and are able to perform tasks that illiterates and preliterates cannot (as demonstrated by participants’ strong performance on the Delete Segment Task), fundamental differences persist in the phonological processing of syllables vs. segments.

Before turning to a discussion of the relationship between the phonemic awareness tasks and reading ability, we address the issue of task order. Is it possible that participants simply performed better on the syllable-based tasks because they always followed the segment-based tasks? It is unlikely that the large and significant difference in syllable versus segment performance is due to task order alone. If task order were a significant factor in subject performance, one would expect that participants would not only do better on syllable-based tasks than on segment-based tasks, but that their performance on tasks that came later in the experiment (i.e., reversal operations) would exceed their performance on earlier tasks (i.e., deletion operations). In fact, this did not happen with either segment or syllable based tasks.

The chart below is another representation of participants’ mean correct response rates, ordered by unit of manipulation (segments vs. syllables) and then by task order:
Figure 4.4: Comparison of Task-Type Performance

Clearly, participants’ performance did not improve over the course of the experiment as a result of task familiarity. In fact, in the case of the segment tasks, it got worse: a pairwise comparison of participants’ performance on the Delete Segment Task (Task One; mean correct response rate = 9.27) and the Reverse Segment Task (Task Five; mean correct response rate = 2.36) indicates that there was a significant effect for operation type, $t(32) = 11.41, p < .001$, with participants performing significantly worse on the task that came later in the study. (Participants also performed significantly worse on the Substitute Syllable Task than on the Delete Syllable Task, $t(32) = 9.70, p < .001$.)

One might argue that any task order effect is subsumed by the relative difficulty of, say, reversal tasks vs. deletion tasks. This has a certain intuitive appeal; in a reversal
task, participants must in a sense retain twice the segment/syllable information to perform the task correctly.

If reversal tasks are simply more difficult than deletion tasks, participants should do worse on the Reverse Syllable Task than the Delete Syllable Task. Yet, a task order effect would predict that participants would do significantly better on the reversal task – the sixth phonological task in the experiment, and the third task involving the manipulation of syllables. In fact, a pairwise comparison of participants’ performance on the Delete Syllable task (mean correct response rate = 10.24 of 12) and the Reverse Syllable Tasks (mean correct response rate = 10.45 of 12) found no significant difference in participants’ performance. One can’t argue that task difficulty and effect of task order simply “cancel each other out,” or we’d expect to find no difference between Segment Deletion and Reversal.

Thus, the data suggests that the significant difference between participants’ performance of segments and syllables cannot be explained by a task order effect alone, and is much more likely to be the result of participants’ differences in processing segments vs. syllables. Nevertheless, in a future experiment, one could control for task order.

4.6.2. Results and Discussion: Comparison with Reading and Analytical Ability

The written tests of reading ability and analytic ability were scored according to the answer sheet in the Graduate Record Exam instruction book. The mean correct response rate on the reading test was 14.21 (out of 27) with a standard deviation of 5.23.
The mean correct response rate on the analytical test was 3.88 (out of 10) with a standard deviation of 1.99.

4.6.3. Total Segment Score and Total Syllable Score

In order to best compare participants’ segment processing and syllable processing skills with reading ability, two aggregate measures of task performance were computed: “total segment score” and “total syllable score.” These scores correspond to participants’ combined performance on the three segment-based tasks and the three syllable-based tasks. An one-way analysis of variance yielded no significant differences in participant performance with regard to group (list); Group A and Group B did not differ with regard to Total Segment Score \(F(1,32) = 3.302, p > .05\) or Total Syllable Score \(F(1,32) = 1.607, p > .05\).

Additionally, total segment score and total syllable score were computed a second time, after the exclusion of any items which all participants in a group got correct or incorrect. This exclusion serves to minimize any item effect (i.e., the ease or difficulty of a particular stimulus, rather than the ease or difficulty of the task) on the relationships being analyzed. A brief discussion of the excluded items is included at the end of this chapter.

In the discussion that follows, the term “all items” refers to results based on the complete data set, whereas “item exclusion” refers to results based on the data set with the exclusion of items which garnered 100% correct and 0% correct response rates.
4.6.4. Results & Discussion: Sound Awareness and Reading Ability

In the previous section, evidence was presented that participants demonstrated significant differences in their performance on segment-based tasks vs. syllable based tasks. In this section, the question to be addressed is whether participants’ performance on phonemic awareness tasks is related to their reading and/or analytical abilities.

It is predicted that performance on segment-based tasks will be a significant predictor of reading ability, independent of reading ability. It is not expected that performance on syllable-based tasks will have an effect on reading ability.

Tables 4.11 and 4.12 present the descriptive statistics for the four aggregate measures to be analyzed in this section:

**Table 4.11: Mean & Standard Deviation (All Items)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Score</td>
<td>14.21</td>
<td>5.23</td>
</tr>
<tr>
<td>Analytical Score</td>
<td>3.88</td>
<td>1.99</td>
</tr>
<tr>
<td>Total Segment Score</td>
<td>14.06</td>
<td>4.96</td>
</tr>
<tr>
<td>Total Syllable Score</td>
<td>27.30</td>
<td>5.99</td>
</tr>
</tbody>
</table>

**Table 4.12 Mean & Standard Deviation (Item Exclusion)**

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Score</td>
<td>14.21</td>
<td>5.23</td>
</tr>
<tr>
<td>Analytical Score</td>
<td>3.88</td>
<td>1.99</td>
</tr>
<tr>
<td>Total Segment Score</td>
<td>13.12</td>
<td>5.13</td>
</tr>
<tr>
<td>Total Syllable Score</td>
<td>21.76</td>
<td>5.86</td>
</tr>
</tbody>
</table>

Tables 4.13 and 4.14 present the Pearson correlations between the four aggregate measures; note the relationship between the two sound awareness measures (total segment and total syllable score) and reading score:
Table 4.13: Inter-Correlation Table (All Items)

<table>
<thead>
<tr>
<th></th>
<th>Analytic Score</th>
<th>Total Segment Score</th>
<th>Total Syllable Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Score</td>
<td>0.284</td>
<td>.594***</td>
<td>0.544**</td>
</tr>
<tr>
<td>Analytic Score</td>
<td>0.143</td>
<td>0.143</td>
<td>0.376*</td>
</tr>
<tr>
<td>Total Segment Score</td>
<td></td>
<td></td>
<td>0.635***</td>
</tr>
</tbody>
</table>

*** p < .001; **p < .01, *p < .05

Table 4.14: Inter-Correlation Table (Item Exclusion)

<table>
<thead>
<tr>
<th></th>
<th>Analytic Score</th>
<th>Total Segment Score</th>
<th>Total Syllable Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading Score</td>
<td>0.284</td>
<td>.522**</td>
<td>.355*</td>
</tr>
<tr>
<td>Analytic Score</td>
<td>0.078</td>
<td>0.078</td>
<td>0.15</td>
</tr>
<tr>
<td>Total Segment Score</td>
<td></td>
<td></td>
<td>.736***</td>
</tr>
</tbody>
</table>

*** p < .001; **p < .01, *p < .05

Whether items were excluded or not, both total segment score and total syllable score had a significant (p < .05) zero-order correlation with reading score. In neither case was total segment score correlated with analytical score. The correlation data alone might suggest that both phonemic awareness measures are associated with reading ability; however, when analyzed by multiple regression, only total segment score had a significant effect in the full model.

The relevant statistics are presented in Table 4.18, with discussion following:
Table 4.15: Summary of Stepwise Multiple Regression Analysis for Reading Performance (All Items)

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>seB</th>
<th>Beta</th>
<th>$R^2$</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Included variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Segment Score</td>
<td>0.625</td>
<td>0.152</td>
<td>0.594</td>
<td>0.353</td>
<td>4.109</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Excluded variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical Score</td>
<td>0.204</td>
<td></td>
<td>1.417</td>
<td>0.167</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Syllable Score</td>
<td>0.281</td>
<td></td>
<td>1.533</td>
<td>0.136</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data (all items) were analyzed by multiple regression, using the stepwise method. The regressors were analytical score, total segment score and total syllable score; the dependent variable was reading score. The overall relationship was significant, $F(1,31) = 16.880, p < .001$. In the model, only the effect of total segment score was significant ($t = 4.109, p < .001$). Neither analytical score nor total syllable score were significant predictors of reading score. This was the predicted outcome; when controlling for analytical score and total syllable score, only total segment score was a significant predictor of reading ability.

Reading score was positively related to total segment score, increasing by 0.594 points for every extra total segment score point. This variable accounts for 35.3% of the variance in reading score (as measured by $R^2$). The relationship between reading score and total segment score is demonstrated in figure 5.3, a scatterplot of total reading score and total segment score, with regression line:
In order to minimize any item effect, the data were reanalyzed by multiple regression (stepwise) after the exclusion of items with 100% correct and 0% correct response rates. The relevant statistics are presented in table 4.16:

**Table 4.16: Summary of Stepwise Multiple Regression Analysis for Reading Performance (Item Exclusion)**

<table>
<thead>
<tr>
<th>Included variables</th>
<th>B</th>
<th>seB</th>
<th>Beta</th>
<th>R²</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Segment Score</td>
<td>0.531</td>
<td>0.156</td>
<td>0.522</td>
<td>0.273</td>
<td>3.408</td>
<td>0.002</td>
</tr>
<tr>
<td>Excluded variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analytical Score</td>
<td>0.245</td>
<td></td>
<td></td>
<td>1.638</td>
<td>0.112</td>
<td></td>
</tr>
<tr>
<td>Total Syllable Score</td>
<td>-0.064</td>
<td></td>
<td>-0.281</td>
<td>0.781</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The findings bolster the findings from the all-items analysis. Again, the overall relationship was significant, $F(1,31) = 11.616, p < .01$, and only the effect of total segment score was significant ($t = 3.408, p < .01$). Neither analytical score nor total syllable score were significant predictors of reading score. Reading score was positively related to total segment score, increasing by 0.522 points for every extra total segment score point. In the item-exclusion analysis, total segment score accounts for 27.3% of the variance in reading score (as measured by $R^2$).

The models above comply with standard assumptions of multiple regression analysis. It is worth noting the significant correlation between total segment score and total syllable score ($r (31) = .736, p < .001$ in the “all items” analysis). Some have expressed concern about the validity of the stepwise method when two covariates are highly correlated (see Derksen & Keselman, 1992, among others). Even though the colinearity statistics fall within the acceptable range (for Total Syllable Score, Variance Inflation Factor/VIF/ = 1.675, Tolerance = .596), the data were also analyzed by (non-stepwise) multiple regression. In this analysis, the same predictions were validated: total segment score (but not total syllable score) was found to be a significant predictor of reading score, independent of analytical ability.\textsuperscript{10} This was true for both the all-items and item-exclusion analyses.

\textsuperscript{10}The data, without item exclusion, were analyzed by multiple regression, using as regressors total segment score, total analytical score, and total syllable score. The overall relationship was significant, $F(3,32) = 6.9, p < .01$. Only the effect of total segment score was significant ($t = 2.631, p < .05$). Segment score accounts for 33.8% of the variance in reading score (as measured by $R^2$). With analytical score and syllable score held constant, reading scores were positively related to total segment score, increasing by 0.588 points for every extra segment score point.
So, in summary, the predictions about the relationship between adult phonemic awareness and reading were borne out in four different statistical analyses: all items/stepwise regression, item exclusion/stepwise regression, all items/standard multiple regression, item exclusion/standard multiple regression. The findings are clear: adult performance on segment-based tasks, which tap into their phonemic awareness skills, is a significant predictor of reading ability, independent of analytical ability. The same cannot be said of performance on syllable-based tasks; participants’ performance on these tasks was not a significant predictor of reading score. This was an expected result; because syllable-based tasks tap into lower-level sound awareness (vs. phonemic awareness), the tasks are not teasing out differences which might be related to reading ability. This finding is consistent with the fact that adults performed quite well on the syllable-based tasks, and significantly better on those tasks than they did on paired segment-based tasks.

The implications of these findings are discussed in the next chapter, following a brief section on the items which were discarded in the item-exclusion analysis.

Further, a multiple regression analysis was conducted on the same variables after the exclusion of items with 100% and 0% correct response rates. Again, the overall relationship was significant, \( F(3,32) = 4.943, p < 0.01 \), and only the effect of total segment score was significant \( (t = 2.367, p < .05) \). In the item exclusion analysis, segment score accounted for 41.6% of the variance in reading score (as measured by \( R^2 \)). With analytical and syllable score held constant, reading scores were positively related to total segment awareness score, increasing by 0.438 points for every extra segment score point.
Discussion of Excluded Items

In the Delete Segment Task, there were two items that all participants got correct: statue and stucco. Only one subject missed sticky, the other s-obstruent cluster. As discussed in Chapter Three, responses were marked correct if they conformed to theories of extrametricality.

In the Delete Syllable Task, there were no items that all participants got incorrect. There were seven items which all participants got correct, which were quarry, franchise, scarcely, music, clergy, fresco, and swallow. There appears to be no difference in phonological pattern between the items that all participants got correct vs. those that all participants did not get correct. This may be explained by the fact that participants, on the whole, performed extremely well on the Delete Syllable Task, and made few errors.

In the Substitute Segment Task, there were no items that all participants got correct. There were three pairs of stimuli which all participants got incorrect: (1) brandish/tractor, (2) drastic/slogan, and (3) traction/clanging. It is interesting that brandish/tractor gave participants difficulty; because it was the only pair (on either list) for which transposing the entire onset of the second word /tr/ would yield the same results as transposing only the first phoneme /t/. It seems that participants may have been thrown off by this, and may have second-guessed their responses. Drastic/slogan is one of the pairs that involves an s-cluster. However, there were other pairs on the same list with s-clusters (e.g., crumpet/slender) to which some participants gave correct responses, so no generalizations can be made. There is nothing distinct about the traction/clanging
pair. In fact, participants made so many errors on this task (with only 3 or 4 participants getting any given response correct), it is difficult to categorize the excluded items.

In the Substitute Syllable Task, there were no items that all participants got correct or incorrect, so all items were included in the final analysis.

In the Reverse Segment Task, there were no items that all participants got correct. The three words which participants got incorrect were *hydrate*, *cyclone*, and *vibrate*. These were the only items on either list with tense (long) vowels in the first syllable, which might lead participants to prefer a CV.CCVC (vs. CVC.CVC) syllabification. This could create two problems for participants. First, in the cases of *hydrate* /hɔy.dreyt/ and *vibrate* /vɔy.breyt/, the segment reversal for a CV.CCVC syllabification would result in the responses of /dɔy.hreyt/ and /bɔy.vreyt/, both of which contain syllable-initial clusters /hr/ and /vr/ that violate the phonotactics of English. Second, a CV.CCVC syllabification of a stimulus item requires that participants extract the first consonant of the second syllable from a consonant cluster (vs. simply reversing the whole onsets in a CVC.CVC word like *fabric* /fæb.rɪk/). Because this puts an extra burden on the subject (he/she must break up an onset and then reverse two segments), it is in a sense combining aspects of the Delete Segment and Reverse Segment tasks, and it is not surprising that participants did not do well.

In the Reverse Syllable Task, there were no items that all participants got incorrect. The items that all participants got correct are not distinguished from other list
items by any notable phonological characteristics. They were *baptize*, *combat*, *garlic*, *dictate* and *cyclone*. 
5.0. CONCLUSION

This dissertation has examined the nature of phonological and phonemic awareness in literate adults. In this final section, it will be shown that:

1. Despite years of reading experience, adults continue to be more syllabically aware than phonemically aware,
2. Even though all adults are phonemically aware to some degree, adults continue to demonstrate differing levels of phonemic awareness,
3. Phonemic awareness is a unique predictor of reading ability in adults, independent of syllabic awareness or analytical ability.

Let us explore each of these conclusions in turn.

5.1 Syllabic vs. Phonemic Awareness

The role of the syllable as a unit of phonological processing has been studied for thirty years. In some ways, the view of the syllable as a unit of perception has come full-circle. Mehler (1981) declared the syllable (as opposed to the segment) the primary unit of speech processing. Subsequent work over the next two decades called this position into question, noting that the particular phonological structure of a language (phonotactic constraints, ambisyllabicity, language-specific prosody) plays a significant role in lexical access.

In more recent years, Cutler and like-minded colleagues have refined the idea of a language-universal role for the syllable in speech processing, the Possible Word Constraint:

Across the world’s languages, possible parses of continuous speech consist of chunks no smaller than a syllable. … The size or nature of the syllable does not appear to matter: any syllable will do. The syllable therefore does appear to have
a central role to play in speech processing. … the syllable appears to be the measuring stick against which viable and unviable parses of continuous speech are judged. Syllables form acceptable chunks in the ongoing lexical parse of the speech stream; nonsyllabic sequences do not” (Cutler et. al., 2002, p. 191)

The PWC posits a universal role for the syllable in phonological processing. Though the PWC has had its detractors, it stands to reason that the syllable – as a unit of rhythm, a unit of prosody, and a larger unit of language – is processed differently from the segment.

The tasks in the previous chapter tested whether adults literate in an alphabetic orthography – participants who clearly have a concept of “phoneme” and some ability to manipulate phonemes – process segments differently than syllables. Norris et. al. (1997), in their formulation of the PWC, found that participants were able to delete (segment off) an initial syllable (va\textipa{f}f\textipa{p}p\textipa{e}l) better than an initial phoneme (\textipa{f}a\textipa{p}p\textipa{e}l) in a word-spotting study. The results of this study demonstrated that adults were able to delete, substitute and reverse syllables more readily than segments. Overall performance on syllable-based tasks was superior to that on segment-based tasks, and when the tasks were difficult enough to generate substantial error rates among participants (i.e., in the substitution and reversal tasks) participants fared better on the syllable-based tasks in each pair-wise comparison.

Thus, there is evidence that that literate, English-speaking adults continue to be more syllabically aware than phonemically aware. Perhaps because syllabic awareness is such a fundamental, foundational skill, it bears no relationship to reading ability, as does phonemic awareness.
5.2. Differentiated Adult Phonemic Awareness and Reading Ability

In Chapter Two, past research on phonemic awareness in children was discussed. A common claim about phonemic awareness is that it exists alongside alphabetic experience. Although there is some evidence that phonemic awareness can develop in the absence of direct alphabetic experience (Mann, 1991), there is a wider swath of evidence that phonemic awareness is found primarily in those with alphabetic experience (Read, et. al, 1986; Morais, et.al., 1986).

Literate, English-speaking college students, are all, to some degree, phonemically aware. In both the Adams (1990) and Treiman (1993) models, literate adults have achieved the highest level of awareness; they are able to manipulate the phonemes in a word, as demonstrated by Delete Segment Task (Adams), and they make spelling mistakes that reflect learned phoneme-grapheme correspondences, like s-u-p-r-i-s-e (Treiman). As they learn to read, they discover that words can be broken down into syllables, syllables into rimes and onsets, rimes and onsets into segments. Ultimately, they break the alphabetic code, learning that written words are composed of segments and those segments correspond in relatively regular ways with the letters of the alphabet. These skills enable them to perform well on phonemic awareness tasks that elude preliterate children and illiterate adults.

---

11 An interesting area of future research might be a study of emergent phonemic awareness in the blind. Pring (1994) found that the blind never go through a logographic (whole-word) stage in reading, since they are unable to see words and word breaks on the printed page. From the very beginning, blind readers must conceive of their writing system alphabetically.
However, as demonstrated in our experiment, not all adults reach the same level of phonemic awareness. Adams only divides phonemic awareness into five levels, and these levels are useful in comparing literate adults with children or illiterates. They do not suffice, though, for comparing adults to each other. Just as phoneme counting serves to distinguish literates and illiterates, the tasks discussed in the previous chapter serve to distinguish very phonemically aware from moderately phonemically aware adults. Recall the six tasks (with corresponding task numbers in parentheses):

<table>
<thead>
<tr>
<th></th>
<th>Segment-based tasks</th>
<th>Syllable-based tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deletion</td>
<td>Delete Segment Task (1)</td>
<td>Delete Syllable Task (2)</td>
</tr>
<tr>
<td>Substitution</td>
<td>Substitute Segment Task (3)</td>
<td>Substitute Syllable Task (4)</td>
</tr>
<tr>
<td>Reversal</td>
<td>Reverse Segment Task (5)</td>
<td>Reverse Syllable Task (6)</td>
</tr>
</tbody>
</table>

Phoneme deletion, substitution and reversal tasks all tap into Adams’ highest level of phonemic awareness, but as noted in the previous chapter, some types of manipulations are more difficult than others (e.g., reversal is harder than deletion). This, combined with the manipulation of different phonological units (segments and syllables), means that some tasks are more difficult than others, and that the variance in task difficult might tease out more phonemically aware participants from less phonemically aware participants, even though all literature adults are, to some degree, phonemically aware.

Recall that in phonemic awareness studies with children, the main conclusion is that reading ability and performance on phonemic awareness tasks are positively correlated. An even more interesting finding from children’s studies is that performance on more difficult measures of phonemic awareness (e.g., phoneme counting tasks) is
more likely to be correlated with reading ability than a lower level measure (e.g., odd-man-out tasks).

As discussed in Chapter Three, even fluent adult readers pay attention to the graphophonic details of words when reading. It was therefore predicted that participants’ performance on segment-based tasks (which tap into the highest levels of phonemic awareness) would be a predictor of reading ability; this proved to be the case. Though both total segment score and total syllable score were correlated with reading ability — and highly correlated with each other — only total segment score was a predictor of reading ability in a multiple regression analysis. Analytical ability was not correlated with reading ability or total segment score, and was not a predictor of reading ability in a regression analysis. In other words, participants’ task performance is not driven by a non-linguistic strategy skill.

So, adults do exhibit differing levels of phonemic awareness even if they are literate; the playing field is not level. Phonemic awareness is not an on-off switch; some adults are more phonemically aware than others, and their phonemic awareness skill (as measured by segmental manipulation tasks) is a predictor of reading ability. Because syllabic awareness is a lower-level skill which develops in the absence of reading experience, it is not a predictor of reading ability.

5.2.1. Causality and Continued Improvement

In chapter three, the question of causality was discussed; historically, it has not been clear whether phonemic awareness skills in children lead to better reading, or whether print exposure and reading activities foster phonemic awareness (Ziegler and
Recent research has attempted to address this question directly by testing the effect of phonemic awareness training while controlling for training in other speech units and prior print exposure (Hulme et. al., 2012).

In adults, the causality question is even murkier. It has been suggested that the best way to control for causality in children’s studies is to test kids who possess zero reading skills. While this is difficult to control for with American children because most have had hours of alphabetic instruction before entering school (Mann and Wimmer, 2002; Lundberg et al., 1988), it is logically impossible with literate adults. We know that adult phonemic awareness and reading ability are interconnected, but which is triggering which?

A second, related question with adult readers is whether adults at some point “level off” with regard to their phonemic awareness and/or reading skills. Do either of these continue to improve over time? This is not an issue when studying children, as it is understood that are still developing both sets of skills. Moll & Bus (2011) meta-analyzed 99 studies that focused on leisure time reading of emerging readers, elementary school students and college-aged students. Though they did not address the question of phonemic awareness directly, their analysis argues for an “upward spiral” of causality with regard to reading skill: good emerging readers read more, and thus become better readers over time. Does the upward spiral continue into later adulthood? And what role does phonemic awareness play?

Future study on these questions might be addressed in a longitudinal phonemic awareness training experiment in adults which controls for reading ability. A study
which demonstrated that adults at similar reading levels improve on the basis of phonemic awareness training (but that adults in a control group do not) would address the causality question and isolate the effect of phonemic awareness on improved reading ability.

5.3 **Future Directions**

In addition to the causality question, there are other factors that might be controlled for in a future study.

5.3.1. **Considerations for study replication**

First, to verify the findings suggested here, the study could be replicated with a randomized task order, to address any concerns about a task order effect. Additionally, future studies might exclude [Cj] clusters and s-clusters, as both types of clusters lead to more ambiguous onsets in English than other CC clusters, such as /bl/.

As noted in the previous chapter, the syllabification of intervocalic consonants in English, whether they are alone or as part of a cluster is complicated; there are a number of acknowledged statistically significant syllabication patterns, but few hard-and-fast rules. Derwing (1992) found that illiterates and literates exhibited differing syllabification patterns of intervocalic clusters, with the former more likely to push (legal) clusters to an onset and the latter more likely to split clusters between syllables. It would, therefore, be interesting to explore whether literates and illiterate exhibit differential performance on the syllable-based tasks. (We would, of course, expect a difference in performance on segment based tasks).
Additionally, even though the pilot experiment showed that subjects were not thrown off by an orthography/mismatch in the Delete Segment Task (i.e., they found it no more difficult to delete a first phoneme in *thesis* than in *baby*), the results from the full study indicate that deletion tasks are generally not difficult. Derwig’s findings suggest that it might be valuable to explore the role of orthographic interference in a future sound awareness and reading study; when tasks are difficult, are subjects more or less likely to call upon their knowledge of orthography, and is that a characteristic of good or poor readers? Future studies could manipulate task difficulty to test this theory.

### 5.3.2. Other factors in reading

Though phonemic awareness is the most well-established predictor of future reading skill, recent research suggests that other factors, such as vocabulary size and morphological awareness, are also predictors of reading ability. Some have suggested that as children reach the later elementary grades, these factors may in fact be *better* predictors of reading ability than phonemic awareness alone (Scarborough, 2005).

With regard to vocabulary, several studies have established a robust relation between oral vocabulary in preschoolers and phonological awareness in later elementary grades (Lonigan et al., 2009; Ouellette & Haley, 2013). Perfetti & Hart (2002), focusing on the role of word knowledge in the reading process, proposed the Lexical Quality Hypothesis, which posits that skilled reading depends on high quality lexical representations. As such, vocabulary size may be a confound in studies which seek to establish a relationship between phonemic awareness and reading ability.
Carlson, Jenkins & Bronwell (2013) tested the vocabulary/reading link more directly, and found that vocabulary at age 5 and 6 had a direct, moderate association with reading comprehension at ages 8–10. In their study, they controlled for other factors, such as decoding ability. Similarly, Braze et. al. (2007) tested 16-24 year olds who had not pursued full-time university study. In this population, they found that oral vocabulary knowledge predicted reading comprehension even when controlling for listening comprehension and decoding skill. Stanovich, West & Harrison (1995) found that print experience was a reliable predictor of vocabulary in college students/adults, controlling for memory, IQ and education (see also Stanovich & Cunningham (1992) and West, Stanovich, & Mitchell, 1993).

Given the potential role of vocabulary knowledge in reading ability, a future study on the phonemic awareness/reading link might control for subjects’ vocabulary skills.

Another potentially complicating factor in the study of adults’ phonemic awareness is morphological awareness. In reviewing phonemic awareness studies, some have noted that morphological changes are frequently signaled by phonological changes at the level of the segment. For example, in Turkish, in /evim/ = “in my house,” whereas /evin/ = “in your house”; a phoneme substitution signals a morphological alternation (of course, English has its own less productive examples, e.g. man/men). The morphophonology of some languages is such that morphological awareness and phonemic awareness may be closely interrelated, and develop in tandem (Goswami and Ziegler, 2006; Durgunoglu, 2006). Shankweiler et. al. (1996) suggest that, as readers mature, fine-grained knowledge of relationships among words, including derivational
morphology (via oral and written language), is an increasingly important component of reading skill. Berninger et al. (2010) analyzed the normal development of orthographic, phonological, and morphophonological awareness in students in grades 1-6, and found that while growth in phonological awareness explodes in the younger grades, growth in morphological awareness in grades 3 and 4, as reading skills continue to develop.

So, as with vocabulary skills, a future study on adult readers might control for subjects’ morphological awareness.

5.3.3. Applications

The findings in this dissertation have implications for research on the role of the syllable in processing, and the connection between phonemic awareness and literacy in adults, and for the educational and applied linguistics communities.

This dissertation has established a connection between phonemic awareness and reading ability in literature adults. If that link is confirmed to be causal, there are implications for (1) Adult literacy programs, (2) English-as-a-second-language programs (or any such programs in which the L2 employs an alphabetic orthography), and (3) Reading enrichment programs.

First, let us consider the case of adult literacy programs, in which illiterate adults wish to learn to read and write an alphabetic orthography. Research with children indicates that phonemic awareness and reading ability are highly correlated, and all effective readers are phonemically aware. Adams (1991) claims, "toward the goal of efficient and effective reading instruction, explicit training of phonemic awareness is invaluable" (p. 331). Perhaps, then, phonemic awareness training, rather than mere
phonics training, should be an essential element of adult literacy programs. Ball & Blachman (1991) conducted a study in which they compared the reading performance of three groups of children who received various kinds of training. One group was given traditional phonics (sound-symbol) instruction, a second group received phonics and phonemic awareness instruction (by being taught phoneme deletion and manipulation "games"), and a third (control) group received no instruction. They found that although the group which received both phonics and phonemic awareness instruction outperformed the other groups, "instruction in letter names and letter sounds alone did not significantly improve the segmentation skills, the early reading skills, or the spelling skills of the kindergarten children who participated in the language activities group, as compared with the control group" (B&B, p. 49).

Are we missing the boat in adult literacy programs? Should we do away with Hooked on Phonics and teach adults how to play language games? If there is a phonemic awareness/reading connection in adults, this training would also prove useful for adults learning a language with an alphabetic orthography as a second language. If the adult’s first language has a non-alphabetic writing system, the benefits of phonemic awareness training in adults are clear: phonemic awareness in an essential part of effective reading. However, even if the adult reads and writes an alphabet (and is thus phonemically aware), phonemic awareness training may be useful. As the studies cited in Chapter Three reveal, adults heavily on graphophonic information when reading. Since the second language is sure to contain phoneme-grapheme correspondences which are new to the adult learner and thus more a conscious part of reading, a phonemic awareness
“refresher” (that is, training in the honing or development of phonemic awareness skills) could help in the acquisition of the second /written/ language.

Finally, the development of phonemic awareness skills could prove a successful part of a reading enrichment program. Perhaps alongside *Ways to Enrich Your Word Power* or an Evelyn Wood-style speed-reading course could sit a phonemic awareness training program, designed to improve adult reading ability by fostering greater phonemic awareness skills.
# APPENDIX A: Pilot Task Stimuli & Correct Responses

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Stimulus</th>
<th>Correct Response</th>
</tr>
</thead>
<tbody>
<tr>
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<td>i:ι</td>
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<td>bjuri</td>
<td>juri</td>
</tr>
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<td>ke:sl i</td>
</tr>
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<td>pjup:l</td>
<td>jup:l</td>
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<td>pe:nι</td>
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<td>τουdʒ</td>
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<td>kalig</td>
<td>αlig</td>
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<td>εμαι</td>
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<tr>
<td>baby</td>
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<td>ebi</td>
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APPENDIX B: Stimuli for Tasks One and Two

<table>
<thead>
<tr>
<th>Practice Items</th>
<th>List 1 Stimuli</th>
<th>List 2 Stimuli</th>
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<td>bebi</td>
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<td>translate</td>
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<td>tsәlkol</td>
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<td>gәefәyt</td>
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<table>
<thead>
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APPENDIX C: Stimuli for Tasks Three and Four

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<td>brutal/clipper</td>
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<td>bandage/suction</td>
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<tr>
<td>travel/pliant</td>
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<td>secret/bundle</td>
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<table>
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<th>Test Items</th>
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<td>crimson/twinkle</td>
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<td>quisling/spastic</td>
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<td>flounder/clumsy</td>
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<td>trinket/cluster</td>
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<td>gremlin/plastic</td>
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<td>frosting/blasted</td>
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<td>plaintiff/scarlet</td>
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APPENDIX D: Stimuli for Tasks Five and Six

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## APPENDIX E: Task One Acceptable Responses

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<td>(t)ako</td>
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<td>æido</td>
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APPENDIX F: Task Two Acceptable Responses

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<td>treaty</td>
<td>di, ti, i</td>
</tr>
<tr>
<td>Quarry</td>
<td>ri, i</td>
<td>quasi</td>
<td>zi, si, i</td>
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<td>tk, tk</td>
<td>frenzy</td>
<td>zi, i</td>
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<td>stucco</td>
<td>ko, o</td>
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<tr>
<td>Cubic</td>
<td>bik, ik</td>
<td>fury</td>
<td>xi, i</td>
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<tr>
<td>Franchise</td>
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<td>climax</td>
<td>mæks, æks</td>
</tr>
<tr>
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<td>species</td>
<td>fiz, siz, iz</td>
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<tr>
<td>Clergy</td>
<td>dʒi, i</td>
<td>puny</td>
<td>ni, i</td>
</tr>
<tr>
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<td>zík, ík</td>
<td>proxy</td>
<td>si, i</td>
</tr>
<tr>
<td>Fresco</td>
<td>ko, o, sko</td>
<td>credo</td>
<td>do, o</td>
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<tr>
<td>Swallow</td>
<td>lo, o</td>
<td>statue</td>
<td>tʃu, u</td>
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## APPENDIX G: Task Three Acceptable Responses

<table>
<thead>
<tr>
<th>List 1 Stimuli</th>
<th>correct response</th>
<th>List 2 Stimuli</th>
<th>correct response</th>
</tr>
</thead>
<tbody>
<tr>
<td>blister/presto</td>
<td>plistɔɾ</td>
<td>slander/grizzly</td>
<td>gaendlɔɾ</td>
</tr>
<tr>
<td>princess/blunder</td>
<td>bunsɛs</td>
<td>triplet/bleachers</td>
<td>bʌnpʌlɛt</td>
</tr>
<tr>
<td>blanket/crumple</td>
<td>klæŋkɔt</td>
<td>problem/clobber</td>
<td>kæblæm</td>
</tr>
<tr>
<td>crimson/twinkle</td>
<td>tæmznən</td>
<td>brandish/tractor</td>
<td>trendɪʃ</td>
</tr>
<tr>
<td>quisling/spastic</td>
<td>spɪslɪŋ</td>
<td>drastic/slogan</td>
<td>slæstɪk</td>
</tr>
<tr>
<td>flounder/clumsy</td>
<td>klɔwnɔdɛɾ</td>
<td>crumpet/slender</td>
<td>slæmpɔt</td>
</tr>
<tr>
<td>trinket/cluster</td>
<td>kʊŋkɔt</td>
<td>quagmire/skeptic</td>
<td>skægmæyɪɾ</td>
</tr>
<tr>
<td>gremlin/plastic</td>
<td>ɡremlɔn</td>
<td>crinkle/flanking</td>
<td>fæŋkɔl</td>
</tr>
<tr>
<td>prosper/glisten</td>
<td>ɡrəspɔɾ</td>
<td>brisket/fluster</td>
<td>friskɔt</td>
</tr>
<tr>
<td>frosting/blasted</td>
<td>ɡraʊstɪŋ</td>
<td>proxy/plenty</td>
<td>præksi</td>
</tr>
<tr>
<td>plaintiff/scarlet</td>
<td>skentɪf</td>
<td>swelter/crystal</td>
<td>kɛltɔɾ</td>
</tr>
<tr>
<td>crafty/plasma</td>
<td>praɛfti</td>
<td>traction/clanging</td>
<td>kraisefɪn</td>
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### APPENDIX H: Task Four Acceptable Responses

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<th>List 2 Stimuli</th>
<th>common response</th>
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<tbody>
<tr>
<td>blister/presto</td>
<td>pæstər</td>
<td>slander/grizzly</td>
<td>grizdər</td>
</tr>
<tr>
<td>princess/blunder</td>
<td>blæn'ses</td>
<td>triplet/bleachers</td>
<td>blitfλet</td>
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<tr>
<td>blanket/crumple</td>
<td>klæmknət</td>
<td>problem/clobber</td>
<td>klæbλəm</td>
</tr>
<tr>
<td>crimson/twinkle</td>
<td>twirjkson</td>
<td>brandish/tractor</td>
<td>tækdiʃ</td>
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<td>quisling/spastic</td>
<td>spæslɪŋ</td>
<td>drastic/slogan</td>
<td>slo(ʃ) tik</td>
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<tr>
<td>flounder/clumsy</td>
<td>klæm'dər</td>
<td>crumpet/slender</td>
<td>slæntər</td>
</tr>
<tr>
<td>trinket/cluster</td>
<td>klæskət</td>
<td>quagmire/skeptic</td>
<td>skæpmayə</td>
</tr>
<tr>
<td>gremlin/plastic</td>
<td>plæslən</td>
<td>crinkle/flanking</td>
<td>flæŋkəl</td>
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<td>prosper/glisten</td>
<td>glispər</td>
<td>brisket/fluster</td>
<td>fləskət</td>
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<tr>
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<td>blæstəŋ</td>
<td>proxy/plenty</td>
<td>plənsi</td>
</tr>
<tr>
<td>plaintiff/scarlet</td>
<td>skɔutif</td>
<td>swelter/crystal</td>
<td>kɾıstəɾ</td>
</tr>
<tr>
<td>crafty/plasma</td>
<td>plæsti</td>
<td>traction/clanging</td>
<td>klæŋfən</td>
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APPENDIX I: Task Five Acceptable Responses

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<th>correct response</th>
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<tr>
<td>baptize</td>
<td>τæpbayz</td>
<td>cashmere</td>
<td>mæzkir</td>
</tr>
<tr>
<td>toxic</td>
<td>saktk</td>
<td>septic</td>
<td>tepsik</td>
</tr>
<tr>
<td>hormone</td>
<td>mɔːθhon</td>
<td>hydrate</td>
<td>ταυdhet*</td>
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<tr>
<td>combat</td>
<td>bamkæt</td>
<td>cosmic</td>
<td>mazkik</td>
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<tr>
<td>mastiff</td>
<td>(s)τæ(s)mif*</td>
<td>sentence</td>
<td>τεnsm</td>
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<tr>
<td>dictate</td>
<td>τukdet</td>
<td>fabric</td>
<td>τæbfik*</td>
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<tr>
<td>mystic</td>
<td>(s)tu(s)mik*</td>
<td>mascot</td>
<td>(s)kæ(s)mæt*</td>
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<tr>
<td>publish</td>
<td>lub(p)ɪf*</td>
<td>tarnish</td>
<td>nautɪf</td>
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<tr>
<td>costume</td>
<td>(s)τα(s)kum*</td>
<td>cyclone</td>
<td>laykson*</td>
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<tr>
<td>garlic</td>
<td>laɾɡik</td>
<td>format</td>
<td>mɔɾfæt</td>
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<tr>
<td>phosphate</td>
<td>fasfet</td>
<td>vibrate</td>
<td>ταυbvet*</td>
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<tr>
<td>mustang</td>
<td>(s)τe(s)mæŋ*</td>
<td>darling</td>
<td>laɾdɪŋ</td>
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## APPENDIX J: Task Six Acceptable Responses

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<tr>
<td>baptize</td>
<td>tayzbi̱p</td>
<td>cashmere</td>
<td>mi̱kæʒ</td>
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<tr>
<td>toxic</td>
<td>sikti̱k</td>
<td>septic</td>
<td>tikse̱p</td>
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<tr>
<td>hormone</td>
<td>monhɔɹ</td>
<td>hydrate</td>
<td>(d)æthay(d)</td>
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<td>combat</td>
<td>bætkam</td>
<td>cosmic</td>
<td>mɪ(k)æz</td>
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<tr>
<td>mastiff</td>
<td>tɨf’mæs</td>
<td>sentence</td>
<td>tɪns(ʃ)ən</td>
</tr>
<tr>
<td>dictate</td>
<td>tɛtdik</td>
<td>fabric</td>
<td>(b)ʌkʃæ(b)</td>
</tr>
<tr>
<td>mystic</td>
<td>(s)tikm(ʃ)</td>
<td>mascot</td>
<td>(s)katmæ(ʃ)</td>
</tr>
<tr>
<td>publish</td>
<td>lɪʃpəb</td>
<td>tarnish</td>
<td>nɪʃtəɹ</td>
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<tr>
<td>costume</td>
<td>(s)tumk(ʃ) (s)</td>
<td>cyclone</td>
<td>(k)lonšay(k)</td>
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<tr>
<td>garlic</td>
<td>likɡar</td>
<td>format</td>
<td>mɛtʃɔɹ</td>
</tr>
<tr>
<td>phosphate</td>
<td>fetfæs</td>
<td>vibrate</td>
<td>(b) ætvəy(b)</td>
</tr>
<tr>
<td>mustang</td>
<td>(s)tæŋma(ʃ) (s)</td>
<td>darling</td>
<td>lɪŋdæɹ</td>
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