ADULT ESOL READING COMPREHENSION AND TEXT-TO-SPEECH SOFTWARE

by

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ABSTRACT

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This study involved ten ESOL adults and examines the extent to which text-to-speech (TTS) software facilitates their reading comprehension. The five treatment participants read fifty, 300-word, non-fiction stories and answered six comprehension questions per passage using TTS software, while five control participants read the same fifty passages and answered the same questions printed on paper. Using a pre- and post-test design, data showed two findings. First, control and treatment groups achieved gains on overall reading comprehension at 26 and 25 respectively, but the gains among question types were not equal. Second, participants in both groups enjoyed the stories and questions prompting some to request additional practice. Such results suggest that the combination of classroom instruction and supplemental activities using TTS

software can build reading confidence and motivate students to break reading avoidance behaviors and experience pleasure in reading.

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CHAPTER ONE

INSPIRATION FOR THE RESEARCH

The words of Emma Lazarus inscribed on the base of the Statue of Liberty read, "Give me your tired, your poor, your huddled masses yearning to breathe free, the wretched refuse of your teeming shore; send these, the homeless, tempest-tost to me, I lift my lamp beside the golden door!" (National Park Service, 2006). And come they have. In 1820, the number of immigrants to the US was only 8,385 (2004 Yearbook of Immigration Statistics, 2006) and since then, immigrants have come by boat, on horseback, on foot, in motor vehicles, and more recently, by aircraft contributing to a U.S. population that currently exceeds 300 million (US and World Population Clocks, 2006). According to the 2000 U.S. Census, the number of individuals in the US over the age of 5 whose first language was not English jumped from about 32 million in 1990 to over 47 million in 2000, (Shin & Bruno, 2003). It has been estimated that, in 2007, a quarter of the working population in the US will be adults whose first language is not English and who are struggling to communicate in English (Kim, Collins, & MacArthur, 1997).

Based on the influx of refugees, immigrants, undocumented people, and the American-born children in these groups, it is not surprising that the U.S. Department of Education confirmed that English classes for speakers of other languages (ESOL) comprise the fastest growing segment of adult education (U.S. Department of

Education, 1995). Dr. Whitehurst, Assistant Secretary of Education of the U.S. Department of Education, commented in an interview that adults who struggle with reading are limited to the lowest employment opportunities and have the smallest access to general opportunities in life (Boulton & Whitehurst, 2003). What is particularly shocking is a statement by Lesley Morrow, the Past-President of the International Reading Association, that some states in the US calculate the number of prison cells to construct based on reading scores (Boulton & Whitehurst, 2003). The fact that reading scores are such a good indicator of future prison populations is distressing. I am certainly not suggesting ESOL students will resort to a life of crime if they do not improve reading skills, but the basing of prison construction on reading scores denotes the urgency to offer classroom techniques that will quickly and effectively improve reading skills to help break the cycle of hardships, poverty and crime. Naturally, these social dilemmas are extremely complex and poor reading skills do not directly cause criminal behaviors, but if superior reading affords more social and employment opportunities, then certainly every effort should be made to enhance and encourage reading.

As an ESOL/EFL teacher of adults for the past twenty years, I have been puzzled with the slow progress of reading comprehension improvement of a small number of students who appeared to function on par with classmates by completing homework assignments, participating in class, and earning 70 percent mastery of computerized skill-building reading software assignments. I am puzzled by the fact these students continue to fail to grasp main ideas, inferences and factual questions after

a full semester of reading exercises that included a variety of comprehension questions. It is possible that some of these struggling readers suffer from Attention Deficit Hyperactivity Disorder (ADHD), dyslexia or other learning disabilities. Additional explanations may relate to phonemic awareness, eye movement, reading strategies, reading quantity, or combinations of these elements. Research with this population might allow me, as an ESOL reading instructor, to help these less skilled readers reach their reading grade level so that they more likely will achieve their academic goals and have employment opportunities afforded to more skilled readers. In an ideal world, ESOL instructors could refer students struggling with reading to disability services for evaluation and guidance, but resources are limited, and students may resist such assessments out of fear of the unknown or being stigmatized. Thus, teachers must be creative and experiment with techniques to help reach these students.

In my search for answers, I discovered on campus a text-to-speech (TTS) software system designed to give more reading autonomy to visually impaired students. The software converts scanned text or text files from word processing programs or the internet into speech while simultaneously highlighting the words. Most TTS software packages I am familiar with also allow the reader to control the size of the text and some have a dictionary feature. Some software also allows the reader to control the reading speed and even select the speaker's voice (i.e., a variety of male or female voices). Many TTS software packages (in PC and Mac platforms) are available as a free download from the internet or are an included feature of the operating system. I was inspired to complete a pilot study using this technology with my adult ESOL reading

students. I hope to determine the extent to which TTS features, including the highlighting of words on a computer monitor in a linear fashion synchronized with audible articulation of such lines of text, facilitates reading comprehension. There is some indication that such software might prove useful in that respect. For example, Elkind (1993, 1996, 1998) found gains in reading endurance, reading rate and comprehension in non-ESOL students who used TTS software, yet there is still the need to more systematically gauge such improvements.

In my quasi-experimental study, I randomly selected research candidates from students (then enrolled in ESOL classes at a junior college) who also expressed an interest in participating in the study. The control group read fifty non-fiction, 300-word reading passages printed on paper and then answered six comprehension questions for each passage, also printed on paper. The treatment group read the same fifty passages using TTS software and answered the same six comprehension questions on computers. I then compared treatment and control results from passages 1-10 (which served as pre-test) with passages 41-50 (which served as post-test). The purpose of my study was to determine the extent to which the use of TTS software benefited reading comprehension of adult ESOL students. What I found through inferential statistics (e.g., t-tests and Pearson correlation analyses) was that there were no significant differences in reading comprehension gains between the control and treatment groups, but as the sample size was ten, one cannot extrapolate to the general ESOL population. However, aggregate pre- and post-test scores of six comprehension question types for both control and treatment groups, and aggregate gains for pre- and post-test scores of six

comprehension question types for both control and treatment groups did reveal interesting findings.

CHAPTER TWO

LITERATURE REVIEW

The term "reading" is such an ambiguous term with dozens of meanings and uses ranging from the meanings conveyed by the phrases "reading people" and "reading thermometers" to a teacher reprimanding or "reading out" her students or merely "reading books". Reading is both a psycholinguistic process and a sociocultural behavior. As a psycholinguistic process, reading is complex as it involves an interactive process that involves simultaneous bottom-up and top-down parallel processes. With bottom-up processes, readers must decode or convert text into meaningful information and then with top-down processes the reader must connect the new information to previously acquired knowledge. As struggling readers become more proficient, they are able to focus more energy on top-down strategies. As a sociocultural behavior, reading is connected to the values of a culture. For example, according to the UNESCO Institute for Statistics, the illiteracy rate for the Republic of Mali in Western Africa in 2005 was 70.5% (Estimates and projections of adult illiteracy, n. d.). Perhaps in this culture, the ability to hunt, farm and protect one's family are more valued than reading skills. Even in the United States, some parents do not enjoy reading, do not have reading materials in the home and may value athletics or social gatherings more than reading, and thus their children's reading abilities may be impacted by this sociocultural behavior.

As reading is such a multidimensional activity, it is important to understand traits of good readers. Aebersold and Field (2005) report that successful readers of any language (Clarke, 1979; Barnet, 1989; Anderson, Bachman, Perkins, & Cohen, 1991) are able to do the following:

- Recognize words quickly
- Use text features (subheadings, transitions, etc.)
- Use title(s) to infer what information might follow
- Use world knowledge
- Analyze unfamiliar words
- Identify the grammatical functions of words
- Read for meaning, concentrate on constructing meaning
- Guess about the meaning of the text
- Evaluate guesses and try new guesses if necessary
- Monitor comprehension
- Keep the purpose for reading the text in mind
- Adjust strategies to the purpose for reading
- Identify or infer main ideas
- Understand the relationships between the parts of a text
- Distinguish main ideas from minor ideas
- Tolerate ambiguity in a text (at least temporarily)
- Paraphrase
- Use context to build meaning and aid comprehension
- Continue reading even when unsuccessful, at least for a while.

(Aebersold & Field, 1997/2005, p. 16)

It is not clear if successful readers use all of these behaviors for each reading event, or if some reading behaviors are more important than others. One might surmise these behaviors are also applicable to second language acquisition. Additional research will need to be conducted to address these issues, but there are several reading models that seek to explain the multidimensional mechanisms through three models: bottom-up, top-down and interactive-compensatory reading models.

2.1 Bottom-up Reading Model

According to the bottom-up model, new readers linearly and upwardly progress through a series of phases. During the initial step, focus first falls on graphemes (letters), and subsequent steps involve the reader progressing to syllables and words. Once understanding of the word occurs, the reader moves up through the levels reaching sentence, paragraph and whole document comprehension (Stanovich, 1990). This process becomes automatic with repetition similar to the way new typists who learn to place their fingers on the home row keys and master each letter until gradually over time they begin to type whole words and phrases as single keystrokes/thoughts. With sufficient practice, readers like typists reach high levels of automaticity, and are able to attend to other aspects of their reading.

Thirty-five years ago, Gough published his model of bottom-up reading that argued that readers must identify every letter before ascribing meaning (Gough, 1972). Rumelhart, a contemporary reading researcher of Gough, offers his description of Gough's bottom-up reading process at a seemingly nanosecond level. Logically Gough begins with the eye as *input device* that notices each letter and the *scanner* searches the arrangement of lines and squiggles and identifies the letter which is then stored in the *character register*. Next, the letter is decoded by consulting the *code book* where phonemes (sounds) are paired with the letters and recoded in the *phonemic tape,* and then the *librarian* assembles the letters into a word and consults with the *lexicon* to assign word meaning. Next, the *primary memory* assembles the sentences and then *Merlin* analyzes the sentence and taps into the *syntactic and semantic rules processor* to

discern the true meaning of the sentence. And finally, the sentence travels to the *TPWSGWTAU* (i.e., the place where sentences go when they are understood) (Rumelhart, 1994). Naturally, in this linear and complex system, there are many opportunities for problems which result in a breakdown in reading comprehension. One such potential problem, and an important component to bottom-up processing, is the role of eye movement.

2.1.1 Eye Movement Research

According to eye movement research, readers use three elements of eye movement while reading: saccades, fixations and regressions (Rayner, Chace, & Slattery, 2006). Saccades occur when both eyes of a reader move rapidly in the same direction. Fixations are pauses of eye movement and regressions are when eyes move backward (to the left). An interesting claim by Rayner, et al. (2006) is that new information is only encoded during fixations. If this is true, perhaps the speed of linear, left-to-right highlighting of text with simultaneously activated synthesized speech impairs the natural reading process by inhibiting fixation length or frequency. Rayner, et al. (2006) further explain there is variability regarding typical fixation durations of 200-250 milliseconds among readers depending on text difficulty. Rayner, et al. (2006), as one might surmise, state that the greater the difficulty of syntactic structure and vocabulary in a reading passage, the longer the fixations, the more frequent the regressions and the shorter the saccades. In a study of beginning and skilled reader eye movements, Rayner, et al. (2006) stated that fixation lengths of first graders were often over 350 milliseconds with two-three fixations per word, but saccade and fixation

lengths stabilize at about the fourth grade (Rayner, 1986). As one might expect, poor readers, no matter the age, typically read with more regressions, longer fixation lengths and shorter saccade durations compared to average readers of similar age (Ashby, Rayner, & Clifton, 2005; Chace, Rayner, & Well, 2005).

In an eye fixation pattern study of 48 adult readers at the University of Turku in Finland, participants fell into four categories of readers: (1) Fast Linear Readers (i.e., those that did not demonstrate fixations returning to previous text); (2) Slow Linear Readers (i.e., those that made lots of forward fixations and re-inspected each sentence before moving to the next; (3) Non-selective Reviewers (i.e., those that looked back to previous sentences); and (4) Topic Structure Processors (i.e., those that paid close attention to headings. These reading strategies are found in competent adult readers. However, slow linear readers re-inspected sentences at first reading rather than frequently looking back to previous sentences, suggesting difficulties in comprehension as measured by the poorest summaries of text (Hyona, Lorch, & Kaakinen, 2002). Hyona, et al. (2002) also found that linear reading style is the dominant style and that those that engaged in this style were less skilled linguistically and had smaller capacities of working memory in relation to other types of readers.

If slow linear readers tend to be poorer readers than readers who use other eye movement styles, perhaps the inherent linear nature of TTS is more synchronous with their natural reading patterns and might explain why the software seems to help poorer readers more than it helps better readers. With email, chat-rooms, the internet, and word

processing programs, one may wonder what impact reading from computer monitors has on fixations and reading comprehension.

2.1.2 Computer vs Paper Reading

Having hypothesized that TTS might benefit struggling adult ESOL readers because it assists with building phonological awareness, it occurred to me that there might be differences between reading from a computer monitor and reading from paper. My review of that literature yielded three conflicting results: (1) reading from monitors is more beneficial than from printed text, (2) reading from text is more beneficial than reading from monitors, and (3) there is no significant difference on reading comprehension between the two modes of input.

In a comparison study on comprehension of reading from books vs. reading from computer monitors, it was learned that skimming was 41% slower from a CRT than text printed on paper, but comprehension and reading speed was higher when reading from a high-quality CRT computer screen (Muter & Maurutto, 1991). In a study of 33 fifth- and sixth-graders on the effects of reading text on a computer screen and comprehension differences, data show readers spend more time reading text on computers than text on paper, and that comprehension increases with computerized decoding options such as on-line dictionaries (Reinking, 1988).

However, in another study, data show reading from a computer screen is 20 to 30 percent slower than when reading text printed on paper (Dillon, 1992). In contrast, in a study of 109 undergraduate native English speakers reading text on a monitor data do not support the idea that comprehension decreases with slow rates of speed (Legge,

Ross, Maxwell, & Luebker, 1989). Possible explanations for these conflicting data include the tremendous variability of computer monitors and subjects' interaction with monitors that would be difficult to control. For example, distance and angle between the reader and the monitor, and familiarity with computers would be more difficult to standardize than other features such as contrast and type of lighting in the room (e.g., sunlight, florescent, halogen), screen resolution, line length, inter-line spacing, font (e.g., style, size & color), and length of reading passage. In a similar study of test taking on a computer vs. on paper, it was learned that there was no significant differences on performance, but test anxiety was higher for those tested on a computer (Ward, Hoper, & Hannafin, 1989). While I would agree that some students have more anxiety when using computers, most students complete assignments, write papers and read assignments online quite successfully. Thus, I believe visual input from a computer monitor vs. printed on paper is not a significant factor influencing comprehension.

2.1.3 Phonologogical Awareness, Phonemic Awareness and Phonics

In addition to eye movement research, phonological awareness concepts support the bottom-up reading model, but such an issue has generated a great deal of controversy. There is great debate among reading researchers regarding the influence of phonological awareness, phonemic awareness and phonics on reading comprehension. All of these concepts relate to bottom-up processing of text. Phonics programs are designed to teach the relationship between printed letters (i.e., graphemes) and sounds (i.e., phonemes) and their role in spelling and "sounding out" words to aid in reading comprehension (Ivey & Baker, 2004). Phonics is often associated with pre-reading

activities of toddlers learning letters and sounds and is most effective with direct instruction and in sequence. Knowledge of phonics helps readers answer questions such as "Which letter makes the first sound in dog?" The United States federal government has spent a great deal of money funding research to determine the strength of phonics in building good reading comprehension skills, and the National Reading Panel (NRP) conducted a meta-analysis finding the "systematic phonics instruction enhances children's success in learning to read and … is significantly more effective than instruction that teaches little or no phonics" (p. 9) (National Reading Panel, 2000). Critics, however, argue that students who read beyond the first grade level will not benefit from highly structured phonics drills and that those drills will not promote improved reading comprehension skills (Ivey & Baker, 2004). Several reasons are cited for the ineffectiveness of phonics and they include (a) complexity of rules (Clymer, 1963) and (b) phonics rules that most reliably pertain to infrequent words while the most frequent words have unreliable rules (Adams, 1990). One phonics study stated there are over 160 phonics rules needed to process 6000 one- and two- syllable words and these rules did not cover all the grapheme-phoneme combinations (Smith, 1994). In a study of 40 fifth-grade children that examined the relationship between listening and reading skills, data indicate that while the skills are closely related, struggling to sound out unfamiliar words may interfere with reading comprehension (Berger, 1978). Although Krashen concedes that phonics can aid reading comprehension when it makes the text more meaningful, overall he clearly does not support intensive, systematic phonics instruction for first or second language readers (Krashen, 2004b). Non-

supporters of phonics state that readers will not gain from phonics drills once they have surpassed second grade reading (Ivey & Baker, 2004). This is worth noting because ESOL students in my TTS software study read beyond the fifth grade level as a prerequisite to enter the credit ESOL program.

Much of the research states that phonics is quite different from phonemic awareness and phonological awareness and that phonemic awareness and phonological awareness (PA) are often used interchangeably in the research, but there seems to be a general consensus that phonemic awareness is a subset of phonological awareness as it refers to an awareness at the smaller phoneme level. Phonological awareness, on the other hand, is the ability to manipulate sounds by moving, deleting and combining phonemes, and discriminate between them in both written and spoken words (Liberman & Shankweiler, 1985). An example of moving, deleting and combining phonemes would be if a teacher asked a reader to say the word "cat" and then change the *c* to an *m* and say the new word *mat*. An example of discriminating sounds in both written and spoken words would be the pronunciation of the word *read* in the sentence *I like to read* would be pronounced /ri^{y}d/. A phonologically aware student would know that *read* in the sentence *I read five pages last night* would be pronounced /rɛd/. Phonological awareness also includes larger units of sounds such as syllables and their onsets and rimes (International Reading Association, 1998). When a syllable can be broken down into two parts (e.g. float), the first part /fl/ with a single phoneme or consonant cluster is called the *onset*. The second part /o^{w}t/ which includes a vowel and any following consonants is called *rime* (Smith, Simmons, &, Kameenui, 1994). Phonological

awareness consists of several levels of complexity ranging from rhyming songs, and sentence/syllable segmentation at the less difficult end of the scale and onset-rime blending and segmenting individual phonemes at the higher end (Chard & Dickson, 1999). What impact does phonological awareness have on reading? Research indicates that phonological awareness in kindergarten is highly correlated to later reading competencies and lack of phonological awareness is highly correlated to poor reading (Perfetti, Beck, Bell, & Hughes, 1987; Mann, 1993; Ivey & Baker, 2004).

Regardless of their first language, all ESOL students have difficulties with sound-symbol decoding (Burt, Peyton, & Adams, 2003). Although there is general consensus regarding the high correlation, this does not show causality and therein lies the controversy. One explanation offered for the high correlation between lack of phonological awareness and poor reading skills may be connected to affect. Consider first or second language readers who read aloud or silently, and are encouraged to guess (interactive-compensatory model) when faced with an unfamiliar word. Often these readers make errors which causes comprehensible input failure (Gough, 1983). Reading failure at the onset of one's reading career may contribute to the downward spiraling cycle of poor affect, lack of practice, reading avoidance, and further reading failure (Lundberg & Olofsson, 1993). This phenomenon of proficient readers reading extensively and gaining in reading proficiency while poor readers avoid reading activities and stagnate at their level of reading proficiency has been labeled the Matthew Effect (Stanovich, 1986).

An excellent example exemplifying the Matthew effect is a former ESOL student of mine named Juan. Juan is fairly fluent in listening and speaking, but struggles to read assignments in college-level classes at a junior college. According to Juan, both native and non-native speakers of English in his class, appear to have little difficulty reading assignments, but Juan toils with phonological decoding and invariably becomes confused and gives up. With little reading success to motivate him, Juan chooses reading avoidance strategies and participates in non-reading activities. Without reading practice, Juan's reading skills stagnate and he has the potential to face the cycle of hardships which include limited job and social opportunities compared to those enjoyed by more proficient readers. Perhaps Juan could benefit from a program of Listening While Reading (LwR) such as one conducted in the Netherlands which showed a positive effect on reading skills of reading disabled children (Van der Leij, 1981).

As a key element in decoding vocabulary, it would seem that text-to-speech (TTS) and reading while listening (RwL) would enhance phonological awareness which in turn promotes vocabulary understanding which facilitates reading comprehension. For example, as ESOL learners can attest, not all English words are pronounced phonetically, and less skilled readers often decode *fatigue*, in three syllables such as /fæt • i^{y}• gu^{w}/ instead of the unmarked two syllable pronunciation /fə • ti^{y}g/. In addition to phonological awareness gained in TTS and RwL, learners using bottom-up processes need knowledge of the pronunciation, collocation, spelling, multiple meanings, and morphological and syntactic properties of words (Folse, 2004). Collocations are not idioms, but show a connectedness between words such as *urban sprawl* or *perform an*

operation that does not allow substitutions. Utterances such as *rural sprawl* or *perform a discussion* would most certainly be uncommon (marked) among native English speakers. Morphological properties relate to word structure such as the rules of transforming lexicon from one *ox* to two *oxen* or how *sume* can be paired with *pre-* and *con-* to create *presume* and *consume*. Syntactic properties relate the study of sentence structure and meaning such as *I broke the block with my foot in martial arts class* which differs in meaning from the altered structure *I broke my foot with the block in martial arts class*. These examples of bottom-up processing work simultaneously and parallel to top-down processing.

2.2 Top-down Reading Model

Just like the bottom-up model, the top-down reading model is a linear process, but it is the inverse of bottom-up in that readers begin with higher-levels of cognitive processing (i.e., primarily generating guesses about the text being read) and then using lower levels of cognitive process to verify or refute initial hypotheses. Such top-down reading is often called the *psycholinguistic guessing game* (Goodman, 1967). Additionally, Goodman argues that readers can gloss over words as predictions help construct meaning. To illustrate, imagine Masashi reading stories about the baseball records held by Hank Aaron and Barry Bonds. According to the top-down model, Masashi might only have to read part of a sentence such as *In his baseball career, Hank Aaron hit a total of 755…* and could predict the final word to be *homeruns*. Masashi might glance at the word verifying the first letter to be "h" and then move on to the next sentence.

A related model, schema theory, also supports the notion of a top-down processing model for reading comprehension. In this model, readers use their schema (i.e., knowledge about a topic, depth of vocabulary, knowledge of syntax and elements of particular genres, past experiences, cultural conventions, familial attitudes, religious beliefs, etc.) as they read and compare the text message to what they already know (Goodman, 1967). For example, a text that mentions chips and ovens and baking may initially give the reader the impression the passage is about potato chips or chocolate chip cookies. But when confronted with phrases such as *furnaces heated to 1,000 °C* and *silicon dioxide,* the reader taps into his schema and realizes the temperature is too extreme for food production and thus the article is more likely related to the manufacturing process of microchips for use in a variety of high-tech devices.

Phonological awareness is also important in support of the top-down aspect of schema theory. Chomsky noticed that RwL helps readers to focus more on syntax and semantics of a written text than on individual words, thus enabling them to use contextual clues to determine meaning (Chomsky, 1976). Not surprisingly, research from several investigators indicates that explicitly teaching top-down reading strategies (i.e., activating schema, discerning main ideas from minor ideas and using context clues to guess unknown vocabulary, etc.) may promote higher reading comprehension skills (Alessi, Siegel, Silver, & Barnes, 1982-83; Rich & Shepherd, 1993; Mikulecky & Lloyd, 1997).

2.3 Interactive-Compensatory Reading Model

There are major criticisms of both the bottom-up and top-down models. Two drawbacks to the bottom-up model involve (a) the idea of linear processing and (b) the failure to include the previous experience and knowledge in the processing. An important drawback to top-down model is that when reading topics are completely new and foreign, it is inefficient, impractical and perhaps impossible to make predictions about the reading. Consider Marian, an older Somalian refugee and former ESOL student, who grew up in an impoverished village with little contact with the modern world until emigrating to the US six months ago, sitting in a college ESOL class attempting to read a short, non-technical newspaper article about a new 3D imaging machine acquired by a local hospital to aid in the diagnosis of complex cardiac arrhythmias. It is quite possible this Somalian student has never been to any hospital let alone seen 3D images of a heart rotated. If this student is to grasp any portion of the medical equipment text, another model will be necessary to explain her reading process. Stanovich's interactive-compensatory model may offer insight.

Stanovich, (1981) explains the interactive-compensatory model in the following manner: "A compensatory-interactive model of processing hypothesizes that a pattern is synthesized based on information provided simultaneously from all knowledge sources and that a process at any level can compensate for deficiencies at any other level" (p. 262). In Marian's case, she would rely heavily on her bottom-up processing, and perhaps use top-down processing by scaffolding the 3D imaging device described in the text from an animated 3D greeting on a webpage she recently visited and imagine

how such a "camera" might be applied when diagnosing patients with cardiovascular problems. Marian, who used to watch the slaughter of goats before a festival, is familiar with the heart and other internal organs and used her schema of anatomy to facilitate her understanding of cardiovascular ailments described in the text.

Neither the bottom-up nor the top-down models adequately address all areas of reading comprehension, but the interactive-compensatory model taps into the strengths of both the bottom-up and top-down models. The interactive-compensatory reading model states that readers rely on both bottom-up and top-down processes simultaneously or alternatively depending on the level of reading expertise, purpose for reading, motivation, schema, and knowledge of the subject (Carrell, Devine, & Eskey, 1988/1993). For example, a reader keen on soccer trivia may use his knowledge of the game as well as familiar lexical cues (e.g., soccer jargon), syntactic cues (e.g., word order often used in sports writing), and orthographic features (e.g., exclamations or bold words) to facilitate decoding of an unfamiliar semantic feature such as an idiom used in the article title. Stanovich (1980) added a compensatory feature to Rummelhart's (1977) interactive model which states that if one of the four processors (i.e., orthographic, syntactic, lexical and semantic) fails, other processors will facilitate comprehension. For example, students studying vocabulary are often given cloze homework exercises to review for upcoming tests in which sentences with several cues help students guess the word that fills a blank (e.g. *Beagles, Retrievers, Spaniels as well as other _____ of dog are favorite canines for hunting enthusiasts*). Predicting *breed* or *types* as the missing word supports Stanovich's interactive-compensatory hypothesis

as the lexical information is absent, yet the syntactic processor suggests lexicon that make sense and facilitate sentence comprehension.

2.4 Implications for ESOL Readers

The reading research discussed up to this point primarily describes reading in a first language, and the importance of the interactive-compensatory reading model. But are there any differences between first and second language readers? There are at least four reading differences that distinguish first and second language readers including: (1) strength of vocabulary base and syntactic structure, (2) orthographic features, (3) reading skills in the first language, and the ability to tap into first language reading skills and (4) first language reading attitudes (Grabe, 1993).

First, in describing the discrepancies between first (L1) and second (L2) language readers' strength of vocabulary base and syntactic structure, Singer (1981) states that by the age of six, most children have already acquired well-developed language proficiency and "they have attained sophisticated control over their syntax, they possess a vocabulary of about 5000 words, and they have a phonological system that can adequately communicate their needs" (p. 295). However, ESOL students learning to read in English may not have language skills this sophisticated. Second, in describing first language orthographic features, research shows that ESOL students' orthographic features (i.e., alphabetical vs character based writing system such as Chinese or Japanese) affect word recognition (coding) mechanisms in second language acquisition. (Taylor & Taylor, 1983; Holm & Dodd, 1996; Akamatsu, 1999; Wang, Koda, & Perfetti, 2003). For example, learners from a nonalphabetic L1 may rely more

on orthographic features than phonological features when decoding English words than learners from an alphabetic L1. Third, in describing reading skills in the L1 and the ability to tap into those skills when reading in the L2, it is logical to assume that strong readers in a first language will transfer those skills to second language reading, and yet there is no strong evidence supporting this claim (Alderson, 1984). Fourth, in describing first language reading attitudes, one must consider the sociocultural behaviors in the L1 culture. For example, ESOL students learning to read may come from cultures that do not encourage reading. Furthermore, some ESOL students may not have appropriate reading materials available or the social motivation to read. Anecdotal evidence from my 20 years of ESOL/EFL teaching experience confirms the importance of sociocultural behaviors. For example, in Somalia prior to the 1980s, women were not allowed the educational opportunities enjoyed by males, and have suffered tremendously with English reading, spelling and handwriting issues while Japanese males and females were consistently among the most proficient readers due to the high regard and emphasis on reading skills in Japanese society as well as several years of formal English reading and grammar instruction. In addition to the four reading differences that distinguish first and second language readers, there are two essential concepts that relate to reading in a second language and they are Krashen's monitor model and free voluntary reading.

2.4.1 Krashen's Monitor Model

Up to this point, specific reading problems of ESOL learners have been discussed, but there are other related theories of second language acquisition. Krashen's

Monitor Model and Free Voluntary Reading theory form the cornerstones of my ESOL pedagogical foundation. Beginning in the 1970s, Stephen Krashen, professor emeritus at the University of Southern California, published his Monitor Model of second language acquisition which incorporates five hypotheses. However, this study will primarily deal with only four: a) the Input Hypothesis, b) the Affective Filter Hypothesis, c) the Natural Order Hypothesis, and d) the Monitor Hypothesis. First, for language acquisition to occur, the Input Hypothesis suggests that for messages to be meaningful, information should be presented at a familiar level (i.e., the "i" level) and portions of the message should be marginally beyond the learner's understanding or *i* + 1 level. When the message is too far beyond the learner's understanding, or includes only structures the learner already knows, additional language acquisition will not occur (Krashen, 1985). As will be discussed in further detail later, comprehensible input is vital for all readers and bimodal input may be of particular benefit to ESOL readers. Second, the Affective Filter Hypothesis seeks to explain why everyone is not successful in developing additional languages, and states that affect (e.g., motivation, anxiety level, self-confidence and attitudes) can help or hinder second language skill development through an affective filter. If a student is extremely anxious, the affective filter goes up blocking language input. However, if the student is relaxed or motivated, the affective filter is lowered and comprehensible input is transmitted to the language acquisition device and stimulates language growth (Krashen, 1982). The affective filter can be especially critical for ESOL readers whose sociocultural values do not embrace reading. Third, the Natural Order Hypothesis suggests that language components are

learned in a particular order. For example, the present progressive is acquired prior to plural forms which are acquired prior to possessives (Brown, 1973). The Natural Order hypothesis is important for ESOL readers as they typically lack the vocabulary and grammar of native speakers their own age. Fourth, the Monitor Hypothesis suggests that *acquisition* is responsible for fluency and the *learning process* helps *edit* or *monitor* the language that has been acquired. These mechanisms require sufficient attention to *how* utterances are made and sufficient understanding of language rules (Gass & Selinker, 2001). The Monitor Hypothesis is important to ESOL readers as they must attend to how utterances are made phonologically as well as in terms of choice of lexicon, and syntax.

2.4.2 Free Voluntary Reading

Building on his Comprehensible Input theory, Krashen reviewed numerous correlational studies and found ample evidence for the power of Free Voluntary Reading (FVR). Krashen argues that when first or second language learners are encouraged and free to select reading material according to their own interests and levels, they will read in greater volume which yields greater comprehensible input and enables these readers to attain higher levels of literacy development (Krashen, 1988). While correlation does not prove causality, studies show a positive correlation between free reading and language skills (Lee, Krashen, & Gribbons, 1996, Constantino, Lee, Cho, & Krashen, 1997, Stokes, Krashen, & Kartchner, 1998, Lee, 2001). In addition to traditional experimental studies, there are also powerful case studies on the effects of FVR on the reading comprehension of adult ESOL students. For example, data showed

that extensive reading from the Sweet Valley Kids, Sweet Valley Twins and Sweet Valley High series dramatically improve reading comprehension over the course of one year (Cho & Krashen, 1995a, Cho & Krashen, 1995b). Krashen also describes cases of individuals who attributed their high literacy levels to FVR (Krashen, 1993). Such studies also support Krashen's Affective Filter Hypothesis (1982) in that readers discovered the joy of reading, lowered the affective filter allowing comprehensible input, and continued reading progressively more difficult books in the series yielding evermore comprehensible input. Building on the concepts of FVR, researchers have suggested that avid readers can identify specific books that got them "hooked" on reading and named this phenomenon *home run* books (Fadiman, 1947). Recent research of 214 fourth grade students in Los Angeles reported over 50% identified a *home run* book and this group included low-income and ESOL students (Sprecken, Kim, & Krashen, 2000).

2.5 Call for Research

If one accepts the fact that reading is a complex, multidimensional activity and if one accepts Krashen's notion of free voluntary reading and *i* +1 comprehensible input, and if one further agrees that bimodal input is an excellent way for ESOL readers to attend to and receive this comprehensible input, then there is a need to empirically analyze the extent to which adult ESOL readers' comprehension is facilitated by bimodal input. Yet, there is little research that focuses specifically on these elements. TTS and RwL studies have focused on NES children, adults, and the learning disabled. One study used second language learners but focused on vocabulary recall and another

study concluded that watching English movies with subtitles facilitated language processing, but none have sought to specifically evaluate gains in reading comprehension of six question types with an adult ESOL population using TTS software. Thus, I plan to examine the extent Kurzweil 3000 TTS software (Kurzweil, 2006), which utilizes bimodal input and draws attention to phonological awareness, facilitates adult ESOL reading comprehension.

CHAPTER THREE

METHODOLOGY

The purpose of this study is to explore the extent to which highlighting words on a computer monitor in a linear fashion, synchronized with audible articulation of the words using TTS software, facilitates reading comprehension of adult ESOL students as measured by six multiple-choice question types: main ideas, subject matter, supporting details, conclusion, clarifying devices and vocabulary-in-context. In exploring this issue, I particularly draw upon scholarly literature addressing bimodal input.

3.1 Bimodal Input: Reading While Listening and Text-to-Speech

As the Input, Affective Filter, Natural Order and Monitor Hypotheses are essential to second language acquisition, and comprehensible input through reading is a primary method for this input, then bimodal input that draws attention to such reading input might facilitate reader comprehension through phonological awareness most effectively. Bimodal input is a general term meaning a student reads a passage while simultaneously listening to the same passage helping readers attend to phonological cues that facilitate comprehensible input. There are two basic types of bimodal input. First, Reading while Listening (RwL) occurs when individuals listen to a text previously recorded or one that is read by a teacher with learners simultaneously reading the text. The second type, Text-to-Speech (TTS), results when software highlights text on a computer monitor while simultaneously converting text to a

synthesized voice. Bimodal input research suggests three findings: (a) RwL and TTS may contribute to PA, (b) the individuals with the poorest reading skills, including reading disorders such as dyslexia, benefit more than readers with better reading skills, and (c) RwL and TTS reduce reading fatigue, improve enjoyment and increase reading quantity.

ESOL students often have good listening and speaking skills, but are poor readers who read more slowly and inaccurately and expend a great deal of energy decoding text (Elkind, 1998). Phonological awareness (PA) was shown to be improved in second language research studies where individuals simultaneously watched movies, listened to the sound-track in English and read subtitles in English resulting in the facilitation of language processing (Meskill, 1996). In addition, RwL is said to encourage readers to emulate the pre-recorded speaker and such a process may enable readers to expend less energy on phonological decoding and spend more time with sight word recognition strategies (Van der Leij, 1981). Research suggests the bottom-up processing skills used in phonological awareness may facilitate retrieval, as in a study of 262 college students studying French as a foreign language using TTS software. Data show the treatment group who used the computer program to read French passages scored higher ($p<.05$) on a delayed vocabulary test than the control group who read definitions printed on paper (Lyman-Hager & Davis, 1996). Similarly, in a RwL study of 40 adult male volunteers focusing on word recognition, data show readers had significantly better recall when printed words were accompanied by spoken words. The

data suggest RwL benefits overall reading comprehension as well as word recognition (Lewandowski & Kobus, 1993).

Much of the bimodal input research suggests average-skilled readers do not benefit as much as readers with poor reading skills. In a RwL study of 39 third- and fourth-graders, data shows that children whose reading comprehension scores were substantially below listening scores made greater improvements than children whose reading and listening scores were more similar at the start of the experiment (Shany & Biemiller, 1995). Interestingly, the gains in word recognition skills came about when reading in context (Shany & Biemiller, 1995), which supports Krashen's theories on whole language, extensive reading and comprehensible input. A TTS reading comprehension study of 52 below-average fifth-, sixth-, and seventh-grade readers produced data similar to Elkind's (1998) study showing that poorer readers benefited more than better readers from using TTS. In a study of 50 learning-disabled adults, data suggest that participants with slow, unaided reading speed or poor, unaided reading comprehension benefited more from a TTS treatment than those with faster, unaided reading speeds or better, unaided reading comprehension (Elkind, Black, & Murray, 1996). In a unimodal versus bimodal LwR comprehension study of 36 eighth- and ninth-graders, data show that participants with poorer reading skills have better comprehension when exposed to text presented bimodally (RwL) than when presented unimodally (i.e., listening only or reading only) (Montali & Lewandowski, 1996). Further, in a study of 26 college students with poor reading skills, data suggest that

computer reading machines improve comprehension more in individuals with reading skills below the tenth grade than those above the tenth-grade level (Elkind, 1998).

However, in a study of reading comprehension of adult college students using TTS, Higgins and Zvi concluded there was no statistically significant difference in reading comprehension between a group who read passages without the assistance of the TTS software and those that read with TTS software (Higgins & Zvi, 1995). Nevertheless, Higgins and Zvi noticed students with the most profound reading difficulties using the TTS software showed more improvement than students who struggled less with reading comprehension (Higgins & Zvi, 1995). Also, in a study of 28 dyslexic middle-school students using TTS software, data show that 70 percent of the students improved reading comprehension and 40 percent achieved large gains, but fourteen percent decreased reading comprehension scores (Elkind, Cohen & Murray, 1993).

The third component of bimodal input concerns the positive impact on affect. Torgesen & Barker claim that the benefits of reading with TTS software come more from student enjoyment of the technology and their increased time reading rather than phonemic awareness gains (Torgesen & Barker, 1995). Elkind supported this view in his study of adults using TTS in which almost all participants stated they enjoyed using the Bookwise TTS system as it made reading less stressful, easier, less tiring and increased their reading endurance (Elkind, 1996). Research also found poorer readers perceived that they had better comprehension when text was presented bimodally (Chomsky, 1976; Van der Leij, 1981; Montali & Lewandowski, 1996; Higgins &

Raskind, 1997; CAELA, 2005). Bimodal input also seems to have a positive effect on reducing reading fatigue and improving reading endurance (length of time spent reading). A TTS reading comprehension study of 20 college students diagnosed with attention disorder shows that the students had greater reading endurance and less stress and fatigue using TTS software. However, while it did not have a significant effect on overall reading comprehension, it did help students with very poor comprehension (Hecker, Burns, Elkind, Elkind, & Katz, 2002). Davidson & Strucker (2002) found non-native English speakers (NNES) and native English speakers (NES) could improve fluency through studying phonics, syllable patterns and from reading aloud. In considering these findings, though, research on TTS software focused on readers of all ages and it would be difficult to draw conclusions about how age or reading level might affect learning outcomes (Strangman & Hall, 2003).

3.2 The Present Study

The present study exams several subjects as they use the TTS software. The study involves a treatment/control group design, and the research was conducted over a five-week period.

3.2.1 Subjects

Both treatment and control groups were randomly selected from adult ESOL reading students enrolled at a junior college that expressed interest in participating in the study. The control group consisted of two females and three males from Africa, Asia, Central American and South America. Control students ranged in age from 19-36 years with an average age of 25.4 years. The treatment group consisted of one male and

four females from Asia, Central America and South America. The treatment students ranged in age from 18-39 years with an average age of 31 years.

In attempting to examine TTS software and reading comprehension, the present study uses several reading passages and comprehension questions. The author of the non-fiction passages (Pauk, 2001) defines the six question types included in each non-fiction story. Main idea (MI) questions test a reader's ability to discern among choices that are too broad or too narrow or that contain the main idea of a passage. The main idea question choice includes the subject as well as what the subject does or is. Readers determine what point the author is making (Pauk, 2001). Subject matter (SM) questions test a reader's ability to concentrate on the overall theme of a passage (Pauk, 2001). This type of question often asks readers to select another good title for the text. Supporting detail (SD) questions test a reader's ability to recognize and comprehend details in the form of examples, definitions, similes, explanations, comparisons, etc. (Pauk, 2001). Conclusion (C) questions test a reader's ability to infer implied conclusions based on evidence of support in the text, or by applying information to new situations (Pauk, 2001). Clarifying device (CD) questions test a reader's ability to recognize signal and transition words, and techniques an author uses to make a passage more interesting. Some techniques a writer might incorporate include similes, organizational patterns, literal or figurative language, bulleted lists, and words in bold or italics (Pauk, 2001). Vocabulary-in-Context (V) questions test a reader's ability to guess the meaning of unknown words by using a variety of techniques such as noticing tone, using stems or prefixes, and punctuation marks, etc. (Pauk, 2001).

3.2.2 Data Collection

Over the course of five weeks, the control group (five students enrolled in a junior college ESOL reading class) read fifty 300-word non-fiction, paragraphs printed on paper and answered the six types of comprehension questions printed on paper described above for each passage. At the same time, the experimental group (five students enrolled in a junior college ESOL reading class) read and listened to the same paragraphs using TTS software (i.e., Kurzweil, 2006) and answered the same questions electronically. To maintain consistency between the groups, the treatment group learned to open the TTS software window and question window at the same time during computer training conducted prior to the start of the experiment enabling readers to glance at questions and the passage simultaneously, just as control readers with passages and questions printed on one sheet of paper could. In addition to bimodal input and linear highlighting, the treatment group in this study had access to an on-line dictionary, pronunciation guide and thesaurus. Similarly, the control group had access to paper and electronic dictionaries offering pronunciation guides and synonyms. Additionally, in an effort to further control consistency, both the treatment and control groups received similar top-down/bottom-up reading strategy instruction in the classroom; they were required to read a novel outside of class, and they took similar types of tests.

The independent variable in this study was bimodal input (i.e., reading text on a computer monitor while simultaneously listening to a synthesized voice read the text), and the dependent variable was reading comprehension. Some may question the

differences of reading text from a computer monitor compared to reading text printed on paper. However, research indicates comparability. In studies comparing paper-based language tests and computer-based language tests, adult English as a Foreign Language (EFL) students scored comparably on subtests of listening comprehension, vocabulary, grammar and reading comprehension. (Ward, Hoper, & Hannafin, 1989; Bugbee, & Alan, 1996; Choi & Kim, 2003). In these studies, as in my TTS research, both tests had exactly the same questions presented in the same order.

Krashen's Monitor Model is essential to this study for several reasons. First, regarding the Acquisition-Learning Hypothesis, the treatment and control groups in this study were exposed to fifty non-fiction reading passages on subjects ranging from mathematics and science to playwrights and history. Students focused on meaning and were *acquiring* language rather than directly studying how and why sentences were formed in particular ways. Perhaps through the variety of readings, research subjects were exposed to an assortment of writer techniques such as foreshadowing, parody, direct address, or personification. I am unaware of any studies on the natural order of language acquisition of writer techniques, but Krashen does not recommend that teachers cover language items in a particular order; but rather that teachers focus on comprehensible input, and they should address all such techniques as necessary. Writer techniques as well as reading strategies were taught in the instructional component of the ESOL reading classes of both the treatment and control groups, and relate to the Monitor Hypothesis as the theory encourages a focus on form and rules to serve as a bridge between language *learned* and *acquired*. Based on the success I have seen with

the non-fiction stories (used in previous classes and this research), I believe the reading level is neither too difficult, nor too easy, but appropriate regarding the $i + 1$ comprehensible input level. Additionally, past experience with these readings indicate students enjoy the activities, gain self-confidence, and develop reading skills over time, such as determining the main idea. When reading activities are enjoyed by students, the *affective filter* goes down and more language acquisition occurs.

3.2.3 Data Analysis

After control and treatment participants read each of the non-fiction stories and answered the six comprehension questions, I entered the data in a spreadsheet. There were three hundred cells per person as each participant answered six comprehension questions for fifty stories. The number *1* was entered for a correct response and the number *0* was entered for an incorrect response. Data was analyzed at the pre- and post-test level and at the cumulative level for each question type. Stories 1-10 served as the pre-test and stories 41-50 served as the post-test. Aggregate pre- and post-test scores were calculated for each question type. Control pre-test scores were subtracted from treatment pre-test scores to find pre-pre test disparity. Control post-test scores were subtracted from treatment post-test scores to find post-post test disparity. In addition, control pre-test scores were subtracted from treatment pre-test scores to find control-treatment pre-test disparity. Control post-test scores were subtracted from treatment post-test scores to find control-treatment post-test disparity. Aggregate pre-test scores for all question types in the control group and aggregate post-test scores for all question types in the treatment group were calculated to find cumulative gains over the course of

the five-week study. Finally, aggregate pre-test scores were subtracted from aggregate post-test scores for each question type for control and treatment groups to find disparity between control gains and treatment gains. Data revealed both expected and unexpected results.

CHAPTER FOUR

RESULTS

This study had a sample size of five for each group giving a total of ten volunteers. Although inferential statistics are reserved for large sample sizes selected randomly, data were analyzed with t-tests and a Pearson product correlation test. An independent t-test for equality of means was conducted between control and treatment groups on each of the pre- and post question types and revealed no significant differences at the $P<.05$ level. Furthermore, a paired t-test conducted on the disparity difference between the six reading comprehension question types for the control and treatment groups revealed no significant difference in means at the $P<.05$ level. In a Pearson correlation analysis of pre- and post-tests of six reading comprehension question types for control and treatment groups, data revealed no significant correlations at the $P<.05$ level. Despite the lack of significance with these tests, there were interesting findings in the sample of aggregate pre- and post-test scores of six comprehension question types for both control and treatment groups, and aggregate gains for pre- and post-test scores of six comprehension question types for both control and treatment groups.

Table 1 below shows the totals of Control Group (CG) and Treatment Group (TG) scores on pre- and post-tests broken down by question types, along with the disparity between pre- and post-test scores of both groups. Disparity was calculated by

subtracting CG pre-tests from TG pre-tests, and by subtracting CG post-tests from TG post-tests, and these results are listed in the last column labeled *Pre-Pre and Post-Post Disparty*. The bottom of Table 1 shows the aggregate totals for pre- and post-tests for both groups, along with their respective gains. There was only one question type per passage in both the control and treatment groups. Additionally, as there were five participants each in the control and treatment group, and ten reading passages in each pre- and post-test, the maximum score for each pre- and post-test was 50.

Table 1 Aggregate Pre- and Post-Test, and Disparity Scores for Control (CG) and Treatment (TG) Groups by Question Type

Question Type (Max: 50 for each type)	Test Type	(CG) Control	(TG) Treatment	Pre-Pre & Post-Post Disparity
Main Idea	Pre-test	35	36	1+
	Post-test	40	46	6+
Subject Matter	Pre-test	34	33	1-
	Post-test	46	38	8-
Supporting Details	Pre-test	43	39	4-
	Post-test	46	36	10-
Conclusion	Pre-test	38	30	8-
	Post-test	36	32	4-
Clarifying Devices	Pre-test	26	27	1+
	Post-test	33	35	2+
Vocabulary	Pre-test	41	36	5-
	Post-test	42	39	3-
Aggregate Total	Pre-test	217	201	16-
(Max: 300)	Post-test	243	226	17-
	Gain	26	25	1-

The six question types for each passage include: Main Idea (MI), Subject Matter (SM), Supporting Details, (SD), Conclusion (C), Clarifying Devices (CD) and Vocabulary in

Context (V). Each question answered correctly earned one point and an incorrect response earned zero points.

Points were totaled for each pre- and post-test and for the aggregate pre- and post-tests. Disparity between Control Pre-test and Treatment Pre-test for each question type, and disparity between Control Post-test and Treatment Post-test for each question type were calculated. The aggregate of all control pre-tests (i.e., 217) and post-tests (i.e., 243) as well as the aggregate of all treatment pre- (i.e., 201) and post-tests (i.e., 226) were calculated and are listed under the heading Aggregate Total. Disparity numbers with a positive sign (+) indicate the disparity favors the treatment group and disparity numbers with the negative sign (-) indicate the disparity does not favor the treatment group, but favors the control group instead. Over the course of the five-week experiment, the control group read 50 non-fiction, 300-word passages and answered six comprehension questions printed on paper while the treatment group read the same passages bimodally using TTS software and answered the same comprehension questions on the computer.

The disparity between the Control Aggregate Total Pre-Test (i.e., 217) and Treatment Aggregate Total Pre-Test (i.e., 201) in Table 1 show control participants scored 16 points higher than treatment participants. The disparity between the Control Aggregate Total Post-Test (i.e., 243) and the Treatment Aggregate Total Post-Test (i.e., 226) show control participants scored 17 points higher than treatment participants over the course of five weeks. Disparity scores between control participants and treatment participants were within 1 point on MI, SM and CD pre-test scores suggesting control

and treatment groups were equally skilled in processing MI, SM and CD comprehension questions at the onset of the study. However, control participants outperformed treatment participants on C, V and SD pre-test scores by 8, 5 and 4 points respectively suggesting the control group was more proficient in C, V and SD comprehension questions compared to the treatment group. Control participants outperformed treatment participants on SD, SM, C and V post-test scores by 10, 8, 4 and 3 points respectively suggesting that reading text printed on paper was more beneficial in processing SD, SM, C and V comprehension questions compared to reading text bimodally. Treatment participants outperformed control participants on MI and CD post-test scores by 6 and 2 points respectively suggesting reading text bimodally was more beneficial in processing MI and CD comprehension questions compared to reading text printed on paper.

Based on the Aggregate Total Pre-Test scores in Table 1 (i.e., CG=217 and TG=201), it can be argued that control participants were more proficient readers at the onset of this experiment than treatment participants as they outperformed the treatment group by 16 points in the pre-test. However, both control (CG Pre = 217, CG Post = 243) and treatment groups (TG Pre=201, TG Post=226) increased aggregate reading comprehension scores by 26 and 25 points respectively leading one to the conclusion that TTS software offers a benefit to adult ESOL readers equal to the benefit of reading passages printed on paper. This data also supports the research of Higgins & Zvi (1995) who found no statistically significant difference in reading comprehension between a group who read passages without the assistance of TTS software and a group who read

passages with TTS software. However, this conclusion is too simplified as aggregate gains do not tell the entire story of reading comprehension in adult ESOL readers. A study of data at the level of question type may offer more insight.

In Table 2, aggregate pre-test scores were subtracted from aggregate post-test scores for each question type for control and treatment groups. Disparity between control gains and treatment gains were calculated and listed in the last column labeled *Control vs Treatment Disparity*. Numbers with a positive sign (+) indicate disparity favors the treatment group and numbers with the negative sign (-) indicate disparity does not favor the treatment group, but favors the control group instead.

Table 2 Aggregate Gains by Question Type and Control and Treatment Group Disparity

Question Type	Control Gains	Treatment Gains	Control vs Treatment Disparity
Main Idea	5	10	5+
Subject Matter	12	5	7-
Supporting Details	3	-3	6-
Conclusion	-2	2	4+
Clarifying Devices	7	8	1+
Vocabulary	1	3	2+
Aggregate Total	26	25	1-

Treatment participants made the most improvement in MI, CD, SM and V questions with gains at 10, 8, 5 and 3 respectively suggesting reading passages bimodally facilitates the processing of MI, CD, SM and V comprehension questions. However, treatment participants made only a slight gain in C (2) and made negative gains in SD (-3) suggesting reading passages bimodally may interfere with the processing of SD comprehension questions. Control participants made the most improvement in SM, CD, MI and SD questions with gains at 12, 7, 5 and 3 respectively suggesting reading text printed on paper facilitates the processing of SM, CD, MI and SD comprehension questions. Control participants made only a slight gain in V (1) and made negative gains in C (-2) suggesting reading text on paper and processing C comprehension questions is less beneficial to reading bimodally and processing C comprehension questions. Although gains varied, the highest control and treatment gains were clustered around MI, SM and SD questions suggesting the non-fiction passages read on paper or bimodally may have improved performance in the processing of MI, SM and SD comprehension questions.

While this study produced a great deal of quantitative data, it also produced some interesting qualitative results. In impromptu discussions with both treatment and control participants, control participants remarked that they enjoyed reading the stories and believed the activities helped prepare them for their final reading exam. Then too, treatment participants remarked they enjoyed using the TTS software. One student from the control group asked for additional stories and questions to continue practicing. I printed five additional stories, including the comprehension questions, and asked her

to return to my office when finished to review answers and offer feedback. The control student came to my office twice and completed about ten additional stories over the next few weeks. Two or three treatment participants also expressed an interest in reading additional stories using the TTS software and for different reading applications such as reading text found on the internet. I offered training and encouragement, but have no data regarding their private use of TTS in our computer labs. In my twenty years of teaching ESOL, I find it rare for students to seek additional assignments and believe TTS software may offer an additional benefit by tapping into students' intrinsic motivation. Thus, TTS software could be a handy tool for ESOL instructors struggling to reach unmotivated, bored, or frustrated readers. After all, motivation research reveals, aptitude and motivation are the strongest predictors of success in second language acquisition (Skehan, 1989).

CHAPTER FIVE

DISCUSSION AND CONCLUSION

The purpose of this study was to explore TTS software and the extent to which it facilitates adult ESOL reading comprehension as measured by six comprehension question types. T-tests and Pearson correlation tests run on pre- and post-test scores of six comprehension questions in control and treatment groups revealed no significant correlations at the $P<.05$ level. Preliminarily, what this finding indicates is that there are only small differences between reading material printed on paper and reading with bimodal input using TTS software. However, analyses of aggregate pre- and post-test scores of six comprehension question types for both control and treatment groups, and aggregate gains for pre- and post-test scores of six comprehension question types for control and treatment groups were insightful. The control group may have possessed higher reading proficiency at the onset of the study as they scored 16 points higher on the aggregate pre-test compared with the treatment group. Overall however, both groups made gains in comprehension over the five-week study with the control group achieving aggregate gains of 26 points and the treatment group achieving aggregates gains of 25 points suggesting TTS software offers some benefit to adult ESOL reading comprehension equal to that of reading from paper.

Another interesting finding was that the control and treatment groups made higher gains on MI, SM and CD questions and the lowest gains on SD, V and C

questions. The research indicates several models of cognitive hierarchy with Bloom's taxonomy among the most influential. According to Bloom, et al., there are six levels in the hierarchy including: knowledge, comprehension, application, analysis, synthesis, and evaluation (Bloom, Engelhart, Furst, & Krathwohl, 1956). However, later research narrows the hierarchy to three levels: literal, interpretive and applied comprehension (Herber, 1978; Pearson & Johnson, 1978). Herber defines these levels: 1) Literal comprehension questions test a reader's ability to recall information explicitly presented in a passage; 2) interpretive comprehension questions test a reader's ability to summarize, draw inferences and conclusions, and paraphrase; and 3) applied comprehension questions tests a reader's ability to use schema to predict, solve problems, and evaluate based on implicit information presented in a passage (Herber, 1978). Herber's (1978) reading comprehension hierarchy offers insight into the variability of scores as MI, CD, V and C suggesting these questions require greater cognitive skills at the interpretive comprehension level and SM and SD questions required less cognitive processing skills at the literal level. Possible explanations of the poor performance on SD questions by the treatment group include an inadequate schema, and bottom-up decoding issues. Possible explanations of the relatively high gains for MI, SM and CD questions may be traced back to classroom instruction and textbooks which emphasize these top-down and bottom-up reading skills. Alternatively, perhaps a combination of teacher explanation in conjunction with the additional practice of the non-fiction stories and comprehension questions facilitated adult ESOL reading

comprehension regardless of whether the text was printed on paper or presented bimodally.

As there appears to be some benefit to TTS software, it seems logical to revisit qualities of good and poor readers to discover in what specific ways TTS software may facilitate adult ESOL reading comprehension. According to van Dijk & Kintsch (1983), poor readers are too slow and inexact during decoding and over-rely on prediction skills. Less skilled readers tend to commit more resources to word recognition while simultaneously overtaxing a faulty comprehension process (Stanovich, 1990). Thus, perhaps the bimodal input of TTS software is beneficial in helping poor readers to read faster and reduce the burden on the comprehension process. Aebersold & Field (1997/2005) suggest good readers use bottom up strategies such as rapidly recognizing words and analyzing new words. Treatment participants had the option of and were encouraged to increase reading speed gradually which may have resulted in improved automaticity. In addition to bimodal input, treatment participants had access to a dictionary feature which may have facilitated a reader's ability to decode lexicon. Aebersold & Field (1997/2005) further suggest top-down strategies such as reading titles and activating schema to make predictions about the passage as qualities of good readers. Poor readers reading from a printed page may not be in the habit of reading titles, charts and photos prior to reading. However, a benefit of the TTS software is that by default, the computer begins a passage by reading the title. According to the author of *Six Way Paragraphs*, SM questions are designed to activate reader's schema by encouraging readers to predict elements that might be presented in a passage. The

ability to distinguish between major and minor details and to infer main ideas of a passage are also suggested as characteristics of good readers (Aebersold & Field, 1997/2005). The TTS software and reading activities required students to decode the passage and use interpretive cognitive skills to guess the main idea for each story. Aebersold & Field (1997/2005) suggest the ability to concentrate on decoding a passage is a characteristic of good readers and developing concentration skills is exactly the purpose of SM questions as the author of *Six Way Paragraphs* explains: "The subject matter question can help you with the most important skill of all in reading and learning: concentration" (Pauk, 2001, p. x). Pauk further explains that SM questions are designed to help activate schema by having students read the first few lines of a passage and then ask themselves what the passage is about. However, the author's intention for a question does not mean readers followed his guidelines. Readers may simply have used scanning techniques to answer SM questions. Finally Aebersold & Field (1997/2005) suggest the habit to continue reading even in the face of difficulty is a mark of good readers.

5.1 Discussion

From the inception of this research design, I had reservations regarding the efficacy of TTS software on adult ESOL reading comprehension due to eye movement research. I was concerned that the linear highlighting of text from left to right with a simultaneous and synchronized synthetic voice reading the text would negatively interfere with a successful reader's eye movement patterns while reading and result in decoding difficulties. While data cannot be extrapolated to the general ESOL population

due to small sample size, it appears that frequency, direction and length of eye fixation for treatment participants were not, overall, adversely affected by TTS software. In fact, TTS software may have benefited some readers with inefficient eye movement patterns as demonstrated in Table 2 which shows gains in MI, CD, and SM comprehension questions by 10, 8 and 5 points respectively. While huge gains in reading comprehension were not realized among these participants reading between the seventh and eighth grade level, it would appear that results from this study support the finding that TTS software facilitate comprehension more for readers below the tenth grade reading level than those beyond the tenth grade level (Elkind, 1998). Perhaps the TTS software forced these readers to fixate (i.e., encode new information) on each word more efficiently, have a more normal saccade length, and have fewer regressions as more skilled readers. Even if participants stopped the TTS software, repositioned the cursor and re-read a sentence or paragraph, perhaps the software which highlights words from left to right prevented excessive regressions and produced more efficient fixations. Additionally, treatment participants were encouraged to increase reading speed by 5 words per minute every 5-10 reading passages over the five-week study. However, data on reading speed increases could not be recorded due to limitations of technological resources, but would be interesting in follow-up studies.

In unsolicited oral feedback, the majority of students confided they enjoyed the stories and technology. One male student confessed reading with TTS software was less tiring than just reading books and a female student claimed TTS software helped her a great deal. Sentiments expressed to me casually are mirrored in the research, as

Elkind (1998) found greater reading endurance and less fatigue with TTS software. Montali & Lewandowski (1996) also found subjects in bimodal reading research perceived they had better reading comprehension than when simply reading from paper. In addition, TTS software research reveals student enjoyment is a typical outcome (Torgesen & Barker, 1995; Elkind, 1996).

As in the previously mentioned research, the treatment subjects in this study also seemed to enjoy reading with the TTS technology and control subjects appeared to enjoy reading the non-fiction textbook. In fact a few students in the treatment and control groups sought additional reading practice using the modalities they were exposed to during the research. Tapping into the intrinsic motivation of students enough to seek additional homework is a rare occurrence. Did the use of TTS software with non-fiction stories create a *home-run experience* for these students, as Fadiman (1947) describes, in that readers experience an epiphany for the joy of reading? Does bimodal reading with TTS software support the theory of FVR that Krashen (1988) touts as the miracle technique for building language skills? It seems evident that reading assignments with TTS software provide amusement, and if students are enjoying the activity, they may read for longer durations and thus expose themselves to greater quantities of comprehensible input which ultimately leads to improved second language acquisition.

TTS software may be an ideal tool to encourage students not to give up as the TTS software will continue highlighting text in a linear fashion while simultaneously reading the text unless stopped by the reader. Obviously a reader can stop the machine

at any time, but as Newton's first law of motion states, an object in motion has a tendency to remain in motion and a struggling reader may be less likely to give up on a particularly frustrating passage. In fact, previous research reveals that TTS software builds reading endurance (Elkind, 1996) and if students are reading longer, they are exposed to more comprehensible input and building language acquisition skills.

What aspects of TTS software facilitates comprehension? Did bimodal input facilitate bottom-up processing? Did treatment participants avail themselves of the dictionary feature to aid in decoding? Did the linear highlighting of words help readers to increase the number of eye movement fixations promoting greater comprehension? If TTS software facilitates MI, CD and SM comprehension, why did treatment participants make negative gains in SD questions? Are there differences in difficulty among the six comprehension questions? Based on Herber's (1978) comprehension hierarchy, SD questions fall into the literal level of the hierarchy and should be easier to answer correctly than the higher-level interpretive and applied comprehension reading questions. Yet, control participants only gained 3 points over the course of the experiment and the treatment group made a negative gain (-3). Among all question types, treatment participants made the highest gains in MI (10) and CD (8) questions which, according to Herber's hierarchy, are cognitively more challenging in the interpretive level.

A further perplexing factor regarding the data is that question types followed the same order for each passage: MI, SM, SD, C, CD, and V. If a student answered a MI question correctly, what caused a breakdown at the SD question? One possibility for the

high gains in MI questions might be the fact that bottom-up and top-down strategies (e.g., skimming, scanning, context clues, activating schema, organizational patterns, and main idea) are heavily emphasized in the classroom. When teaching main idea test-taking strategies for example, students are encouraged to look at the level of details in multiple-choice answers to determine which choice is too broad, which choice is too narrow and which choice sufficiently covers the writer's intent. Students were even challenged to identify choices that were too broad, too narrow and the main idea for passages they had not read, and several students were consistently successful at this type of warm-up activity. Thus, perhaps treatment participants were relying on test-taking strategies to answer MI questions correctly rather than increasing decoding skills and overall comprehension through bimodal input. The second highest gain for treatment participants was for CD questions and again the increase may have come more from classroom instruction than from the bimodal input of TTS software as students were asked to identify organizational patterns for almost every passage read in class. The third highest gains for treatment participants (5) was for SM questions. In an effort to activate schema in the classroom, students were instructed to read the title and notice any accompanying photos or charts prior to reading a passage in class and then consider what they already knew about the passage. For this reason and the fact that SM questions are at the lowest cognitive level of Herber's hierarchy, the relatively high gains for SM questions is not unexpected. The fourth highest gains for treatment participants (3) was for V questions. This result was somewhat disappointing due to the heavy emphasis in class on using context clues to decode unknown vocabulary and the

fact that treatment participants had a convenient dictionary feature in the TTS software. Participants were asked not to look up the underlined word in the passage as that would appear in the V question, but were encouraged to look up any other unknown vocabulary to facilitate comprehension. As Krashen (1985) suggests, vocabulary in context was explicitly taught and reviewed in the ESOL classrooms to make input more comprehensible. While I do not have empirical evidence, frequent random observational evidence suggested participants did not use dictionaries very often and may have over-relied on guessing vocabulary from context. The fifth highest gains for treatment participants was for C questions. The low gain of C questions (2) is not completely unexpected as these fall under the interpretive question level of Herber's hierarchy and require higher cognitive processing skills in that readers must decode the lexicon and syntax, distinguish between major and minor details, make guesses about an author's implied conclusion and adjust that hypothesis as additional information is gleaned from the passage.

The lowest gain and most surprising finding for treatment participants (-3) was for SD questions. The results are surprising due to the fact that SD questions require the lowest cognitive level (literal comprehension) to process. The answers to SD questions are explicitly stated in the passage and students were provided numerous scanning activities to practice their skills, and yet treatment participants did not perform as successfully as anticipated. Were treatment participants simply careless in answering SD questions? Did a weak vocabulary have in impact on comprehension? In reviewing the 50 SD questions and multiple-choice answers, I noticed a few instances where one

word was used in the passage and a synonym was used in the question (e.g., formed and founded), but overall the vocabulary and syntax were very similar. What might interfere with SD comprehension? In reviewing passage topics (e.g., sunspots, the Supreme Court, ballet, Shirley Chisholm and the human genome), it seems plausible that inadequate schema may be an underlying issue contributing to their negative gains. Some of our ESOL students have only been in the United States a few weeks before registering in classes, may be completely unaware of our court system, and come from a country without a constitution. These are but a few possible explanations of the treatment outcome, but are there any similarities between control and treatment gains?

Interestingly, both groups scored highest in MI, SM and CD and weakest in C, V and SD. Can the high scores be contributed to the influence of in-class instruction, bimodal input, or a combination of the two? Do the findings in this research have implications for ESOL reading instructors and ESOL programs? These issues might be addressed in further studies of greater depth, scope and longevity.

5.2 Conclusion

Although this TTS research serves as a pilot study with ten (five Control and five Treatment) subjects over a five-week period, and cannot be extrapolated to the general adult ESOL population due to small sample size, nevertheless, there were several findings that support my hypothesis and the research literature, and several puzzling findings. First, based on the research literature, I hypothesized that the bimodal input of TTS software would offer some benefit to adult ESOL readers (Lewandowski & Kobus, 1993; Higgins & Zvi, 1995; Shany & Biemiller, 1995; Elkind,

Black, & Murray, 1996; Montali & Lewandowski, 1996; Elkind, 1998) and that TTS software exercises should compliment classroom instruction (Elkind, 1998; Fasting & Lyster, 2005). Does TTS software offer benefits to adult ESOL readers? It appears to offer some benefit for the five treatment participants in this study. For example, treatment participants made the highest gains in main idea, clarifying device and subject matter questions as well as self-reported how much they enjoyed reading with TTS software.

I have described expected and unexpected data, and offered possible explanations, but what does the data reveal about the efficacy of bimodal input? Does TTS software facilitate adult ESOL reading comprehension? The answer is both *yes* and *no*. This question is deceptively simple, and perhaps a more meaningful question might be to what extent does TTS software facilitate adult ESOL reading comprehension? Or, in what ways does TTS software facilitate ESOL reading comprehension? There are a number of variables to consider before answering this question such as reading proficiency level prior to entering the study, question type and motivation. Based on the results of Table 1, the control group appeared to be stronger readers than the treatment group at the outset, as the control group scored 16 points higher on the pre-test than the treatment group. However, the control and treatment groups seemed to have achieved the same level of improvement with aggregate gains of 26 and 25 respectively. Thus, in this pilot study of 10, reading passages bimodally with TTS software and reading passages printed on paper is equally, but not more beneficial. Taking the analysis deeper at the question level, it would seem that classroom instruction in conjunction

with passages read on paper or through TTS software yield increased comprehension for MI, SM and CD questions, but have less benefit for V, SD and C questions. Further, it seems that TTS software may inhibit comprehension gains in SD questions for this group of five treatment participants. This is the most puzzling outcome of the study due to the relative ease of the question type. An additional, unplanned outcome of the study deals with the TTS power to motivate. Perhaps it was the result of the Hawthorne Effect (i.e., the result of special attention the researcher paid to participants during the study), but participants in the control and treatment group seemed to value the reading of non-fiction passages and answering six comprehension questions, and seemed to gain self-confidence through success with the stories which led to heightened motivation in some participants. Having a resource that might reach some struggling or bored readers could mean the difference between a frustrated drop-out resigned to struggle in the cycle of hardship, and an academically and professionally successful member of society with access to greater employment and social opportunities. Will TTS software cure every ESOL reading problem? No, but it might facilitate adult ESOL reading comprehension for some by breaking the negative aspects of the Matthew Effect (i.e., cycle of frustration and reading avoidance) and make reading a pleasurable activity rather than a painful burden. Once reading is pleasurable, the ESOL student may engage in the activity more frequently. ESOL students may even discover their own *home run* book which may motivate them to make reading a more frequent habit. The more ESOL students read, the larger their schema as they are exposed to a variety of topics and

opinions. The more comprehensible input, the greater the proficiency in second language acquisition.

5.3 Implications for ESOL Instructors and ESOL Programs

This study offers implications for ESOL instructors and ESOL programs. First, TTS software might be an excellent way to tap into the intrinsic motivation of truly struggling readers. If teachers can find a way to retain students in the classroom, students are more likely to improve reading skills, achieve their professional goals and break the cycle of hardship caused by poor reading skills. This study is not suggesting TTS software replace classroom instruction, but could serve as a flexible tool for reading teachers to use as supplemental practice. It is also important for ESOL reading teachers to recognize Herber's (1978) comprehension hierarchy when working with a variety of comprehension questions as additional instruction may be necessary to facilitate the processing of higher level questions such as drawing conclusions. Second, as Krashen emphasizes repeatedly, building a book-rich environment with easy access to books of all levels and interests, and then encouraging ESOL readers to avail themselves of this resource will facilitate reading skills through the notions of FVR and comprehensible input. With the wonders of technology, an ESOL program can create this library in an instant and at no cost through Project Gutenberg which currently offers 20,000 free eBooks (Cohen, 1999). ESOL students can legally download books on crime, religion, politics, crafts, horticulture, etc. These eBook files can then be opened in TTS software and enjoyed in the classroom, at home, a computer lab and even on a beach with WiFi capabilities. However, if an ESOL program does not have TTS

software, ESOL students can still receive bimodal input by accessing eBook text files and audio files recorded by humans or by computer synthesis. The audio files are unabridged recordings so ESOL students can read the book on a monitor while listening to the audio file.

Finally, ESOL teachers should assess the bottom-up and top-down reading strategies presented in class and make adjustments as warranted. What I have recognized in the reading textbooks I teach is the lack of emphasize on building vocabulary and greater emphasize on using context clues to facilitate meaning. I will make vocabulary expansion a higher priority and explore techniques to facilitate skills in drawing conclusions.

With additional technology, financial resources and time, this study could be enlarged in breadth and scope to capture ESOL student reading behaviors such as frequency of dictionary use, reading speed and classroom methodology on the decoding of new vocabulary and working with conclusion questions. Pre- and post-research interviews may also provide insight explaining anomalies such as poor SM performance. In these ways research may reveal more effective ways of facilitating reading comprehension in struggling ESOL readers and thereby break the cycle of social and economic hardships caused by weak reading skills.

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BIOGRAPHICAL INFORMATION

John Drezek has been teaching a variety of ESOL classes for twenty years and is always searching for new techniques to improve teaching effectiveness. He became interested in TTS software while teaching at a junior college and developed a reading program to help instruct and motivate struggling readers. He would like to further develop a bimodal input reading program with Project Gutenberg that can be used by students at home whenever they have time. Creating an easily accessible book-rich environment for students is the key to developing second language acquisition skills. In the future, John plans to produce educational videos for use in listening and speaking classes and continue improving methodology for teaching ESOL classes.