THE LOCATION AND EFFECTS OF VISUAL HEMISPHERE-SPECIFIC STIMULATION ON FLUENCY IN CHILDREN WITH THE CHARACTERISTICS OF DYSLEXIA

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Bobbie Jean Koen

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Abstract Cover page

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Abstract

Fluency is often used as an indicator of reading proficiency, but many students with reading disabilities are unable to benefit from typical classroom interventions. Lorusso, et al. (2006) used a modified FlashWord computer program that tachistoscopically presents words in the right or left visual hemi-field (Visual Hemisphere-specific Stimulation or VHSS). They matched the intervention to the specific reading profiles (dyslexia subtypes) of reading disabled Italian students using parameters proposed by Bakker, Bouma, and Gardien, (1990). After 1440 minutes of intervention, their behavioral results show significant gains in fluency, reading accuracy, spelling, and memory. The present study is designed to replicate Lorusso’s work in English and locate through fMRI imaging the processing areas involved in fluency and changes as a result of the FlashWord intervention.

Recent advancements in the conceptualization of fluency (Katzir et al., 2006), define fluency as the automatization of reading processes which results from the automatization of underlying lexical and sublexical skills. This suggests that investigations of the development fluent reading should focus on the fast processing of phonological analysis, as well as underlying skills already linked by fMRI results to specific brain regions. Shaywitz, et al., (2004) focused on three Regions of Interest (ROI) within the core sub-systems supporting the processing of written language in normal readers: the left hemisphere (LH) superior temporal gyrus (STG) in the inferior parietal lobule within the temporoparietal system associated with semantic encoding or

word meaning; the posterior aspect of the inferior frontal gyrus (IFG) within the anterior system associated with phonological encoding and sound/symbol associations; and the LH inferior occipito-temporal/fusiform area (VWFA) within the ventral system associated with orthographic encoding and quick recall of high frequency words. It is hypothesized that achieving fluency in reading will involve automaticity within each of these ROIs and that the intervention will increase fluency scores in students with reading disabilities.

This study involved 15 students aged 8-19 years with reading disabilities randomly assigned to Intervention (N = 9) and Delayed Intervention (N = 6) groups. Based on initial fluency assessments, these subjects were matched to a computerized VHSS intervention, FlashWord, modified, targeting either the right or left hemisphere, or both. The Intervention group completed 1440 minutes of their assigned program, and the Delayed Intervention group participated in regular fluency instruction in their classrooms only during the course of the study. Both groups also contributed fMRI data collected during scans conducted pre- and post-intervention, and post-intervention assessments of fluency.

Analysis of intervention data showed that six of the nine Intervention group subjects (67%) achieved levels of automatic processing (<100 ms as defined by Bakker, et al., 1990) in either left or right visual hemi-field processing. All six of these students (100%) also increased their reading accuracy and rate by an average of 20 wpm. Analysis of fMRI activation maps and ROIs clustered within the core subsystems identified by Shaywitz, et al. (2004), document processing changes in left IFG, left posterior STG, and VWFA that could result from the increase in reading speed. However, statistical comparisons of activation levels in these features were not found to be significant. Analysis of time courses of activation from ROI's within core reading subsystems are also inconclusive regarding the temporal elements of fluency in neurological processing of written language.

Discussion includes analysis of orthographical characteristics of different languages and their impact on this study and the importance of automatization in VWFA. Limitations and future directions are explored.

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Introduction

The arguments for and against the contributions of neuroscience to the field of education, especially in terms of instructional practice, have evolved over the past decade. From Bruer's (1997) insistence that neuroscience was "a bridge too far" because of the inherent limitations of the neuroscience and education argument, the field of cognitive neuroscience has embraced the challenges of understanding the developing brain. For example, a two-day conference held at the University of Pennsylvania in 2005 brought together developmental and educational psychologists with animal researchers and resulted in the collection of conference presentations in the book, *Adolescent Psychopathology and the Developing Brain: Integrating Brain and Prevention Science*. Since Byrnes and Fox (1998) tentatively concluded that educational psychologists should accept neuroscientific findings as being a provocative part of the total pattern of findings that have emerged from a variety of research methods in cognitive science, educational psychologists have become less concerned about the preservation of educational theories which are not supported by what is known about the brain.

Further evidence of a shift in perspective is offered by Varma, McCandliss, and Schwartz (2008) as they effectively highlight the ongoing concerns regarding the distance between education and neuroscience and then, masterfully reframe each one as a potential opportunity for valuable collaboration between the two. They acknowledge that the real challenge is to identify the questions and methods that usefully overlap when years of curriculum development, education research and the wisdom of practice guide future neuroscience research into complex forms of cognition. The field of dyslexia has already benefitted tremendously from the application of neuroscience methodologies, especially functional magnetic resonance imaging (fMRI), which has provided evidence for differences in neurological processing of written information in people with the characteristics of dyslexia. Katzir and Pare-Blagoev (2006) reviewed current dyslexia studies in neuroscience and found that new research methods used in neuroscience can provide converging lines of evidence for traditional educational and psychological methods, help researchers decide among rival approaches, and generate new hypotheses based on knowledge of the brain. Even then, researchers point out the difficulty of communication between the fields (Byrnes & Fox, 1998) and Goswami (2006) goes so far as to suggest that scientists should foster a network of communicators of their research who can effectively translate their findings into educational practice and formulate research questions that can drive useful studies.

This study benefits from the combination of extensive classroom experiences of the primary investigator and practical neuroscientific training guided by the Cognitive Neuroscience Certificate Program at the University of Houston. The active encouragement and endorsement of interdisciplinary practices and research at the College of Education has provided the knowledge and skills to communicate effectively in the scientific realm as well as with educators. As a result, this research is interdisciplinary, blending sound educational theory, the pragmatics of reading skill acquisition, and fMRI technology to investigate the neurobiological foundations of fluent processing of written language. In this study, cognitive neuroscience has a unique opportunity to directly inform educational practice in the remediation of processing dysfunctions that interfere with fluent reading, especially in individuals with the characteristics of dyslexia.

The Problem

As the field of cognitive neuroscience becomes more precise in the identification of the cortical subsystems that support the development of reading, a central question involves the nature of the response in various systems to brain-based intervention procedures. In addition to the promising results Shaywitz, Shaywitz, Blachman, Pugh, Fulbright, Skudlarski, et al. (2004) found regarding the success of explicit alphabetic principle and phonological awareness training with increasing left hemisphere activation in students with dyslexia, studies using visual hemisphere-specific stimulation (VHSS) have demonstrated surprising increases in fluency for reading disabled (RD) readers as well.

Bakker, Bouma, and Gardien (1990) identified children with dyslexia in light of the known hemispheric subservience in learning to read as L-dyslexics or P-dyslexics, based on error analysis, distribution of brain responses, and behavioral measures. They suggest that L-dyslexics predominately generate left hemisphere strategies from the very onset of learning to read and therefore are relatively insensitive to the perceptual features of the text. L-dyslexics manifest a hurried and inaccurate style of reading with many substantive errors. P-dyslexics are children who began the learning-to-read process in the right hemisphere, but never progress from there and so are overly sensitive to perceptual features of the text and read slowly with a fragmented style.

Bakker et al. (1990) theorized that since L-type dyslexics had difficulty using right hemispheric strategies during initial reading, they might benefit from specific stimulation of the right hemisphere and the opposite for P-dyslexics: they had not shifted to left hemisphere processing and so would profit from specific stimulation of the left hemisphere. In general, specific stimulation of a hemisphere can be accomplished by the lateral presentation of reading material in the left visual field or to the fingers of the left hand in L-dyslexics, and in the right visual field or to the fingers of the right hand in P-dyslexics. This study actually treated the children with a wooden tactile training box, in which the child would place their target arm through a hole in the side and manipulate plastic letters in grooves out of sight. L-types were given easy-to-visualize concrete words to form and trace with their left hand, to stimulate the right hemisphere, and P-types were given difficult-to-visualize abstract words to form and trace with their right hand, to stimulate the left hemisphere. While P-dyslexics showed a decrease in fragmentation errors on both word and text reading, L-dyslexics decreased substantive errors only on text reading. The authors identified several limitations in their methodology and intervention that may have contributed to the somewhat mixed results, but the positive effects of even motor stimulation to the less activated hemisphere on reading performance are encouraging. Further, these results suggest that the dyslexia sub-typing procedures appear to be valid techniques for matching interventions to processing systems.

Lorusso, Facoetti, Paganoni, Pezzani, and Molteni (2006) were able to employ computer technology to achieve much stronger results in an Italian population of impaired readers because of the strength of these theoretical and neurobiological foundations. These researchers adopted the sub-typing of students with the characteristics of dyslexia proposed by Bakker, et al. (2001), and added M- type dyslexia: a mixed type demonstrating both slow and inaccurate reading. They extended the theory to propose that M-dyslexia children would benefit from stimulation of both hemispheres, alternately.

Their new technology included a modified version of a computerized system for visual hemisphere-specific stimulation, “FlashWord” (Massutto & Fabbro, 1995). After 1440 minutes of intervention, these researchers used only behavioral measures and found that all students with the characteristics of dyslexia, regardless of their sub-type, improved not only in accuracy and fluency as compared to non-impaired controls, but also showed gains in spelling, memory, and general processing speed. Additionally, the students with the characteristics of dyslexia gained 0.33 syllables / second more in reading speed over the same period of time than their non-impaired controls. These remarkable results suggest that putting pressure on the system by requiring very fast processing of the presented stimuli may produce a greater degree of automatisation of the component processes. It is this automatisation of the underlying lexical and sublexical processes that Wolfe and Katzir-Cohen (2001) validate as critical influences on fluent reading of connected text in their comprehensive definition of fluency.

To summarize the theoretical framework, this study will build on the reconceptualizations of the definitions of dyslexia and fluency and use fMRI to localize brain activity before and after VHSS training in students who qualify with the characteristics of developmental dyslexia. It is designed to test the hypothesis that subtyping students with the characteristics of dyslexia and administering VHSS intervention based on those subtypes (FlashWord-modified and in English), would improve fluency performance across dyslexia sub-types more effectively than other currently used reading fluency programs. The following research questions will be addressed: Regarding post-intervention activation, what brain regions are involved in the training of fast processing in reading? What effects in the brain will signify the development of fluency? To what extent does VHSS training increase fluency scores in students with the characteristics of dyslexia?

Hypothesis

These results are expected to validate previous findings regarding the effectiveness of hemisphere-specific stimulation as an intervention technique for students with the characteristics of dyslexia and to identify those reading subsystems and brain features which are neuronally- involved in the fast processing of written language. These are the three core reading subsystems the Shaywitzes (1999) first documented: the Anterior processing subsystem located in the inferior frontal gyrus (IFG) of mostly the left hemisphere which facilitates phonological encoding, the Temporal-parietal subsystem found in the inferior middle (MTG) and superior temporal gyri (STG) in both hemispheres which provides rule-based analysis and learning, and the Occipital-temporal subsystem found in extra striate areas located posterior to V1which applies orthographic encoding and the visual-word form area (VWFA) which supplies sight words. It is hypothesized that developing fluency will be manifested in increasingly faster processing in each of these regions of interest (ROIs), as determined by analysis of onset of stimulus and onset of activation in the ROIs. Comparing the activation maps of the students with the characteristics of dyslexia who participated in the FlashWord Intervention condition with those of the students in the Delayed Intervention condition should reveal the specific effects of the VHSS training on the processing activities in the reading core sub-systems. These results should underscore the effectiveness of dyslexia subtyping for matching specific intervention strategies and the resultant increase in processing speed.

Statistical analyses using multiple regression techniques should produce the relative influence of the ROIs on the development of fast processing. It may be that a pattern is detected where the impact of the anterior system is stronger before the intervention and that the strength of influence shifts to the VWFA as the systems begin to automatize, as well as a shift from the right hemisphere to the left hemisphere, found by Licht, Bakker, Kok, and Bouma (1988) using event related potentials (ERPs) and Shaywitz, Shaywitz, Fulbright, Skudlarski, Mencl, et al. (2002) using fMRI technology.

By comparing the fluency scores from the beginning of the semester and the end of the semester of the children with the characteristics of dyslexia who completed the VHSS intervention with those who did not, the difference is expected to quantify the greater increases in fluency achieved by the students with dyslexia who completed their assigned intervention. This should clearly demonstrate the efficacy of this intervention with this special population and within all subtypes.

Review of Related Literature

Dyslexia

The International Dyslexia Association recently updated a working definition of developmental dyslexia from 1994 to reflect the advancement of understanding in the field. The most important change was describing dyslexia as “a specific learning disability that is neurobiological in origin” (Lyon, et al., 2003). As early as 1891, evidence from lesion studies led the French neurologist, Dejerine, to suggest that a portion of the left posterior brain region is critical for reading. Another posterior brain region more ventral in the occipito-temporal area was described in 1892 (as cited in Lyon, et al.). However educationally, the students with reading disabilities presented a wide range of skill dysfunctions that made research efforts disparate and classroom interventions inexact. Converging data from a variety of neurobiological investigations, but especially from functional magnetic resonance imaging, support the current belief that there are differences in the temporo-parieto-occipital brain regions between dyslexic (RD) and nonimpaired (NI) readers. Goswami (2008) found that analysis of results from different technologies, including PET, fMRI, MEG, and EEG using different research questions, consistently show that children with developmental dyslexia display hypoactivation of crucial parts of the network of areas involved in word recognition and an atypical pattern of continuing right hemisphere involvement.

Pugh, Mencl, Jenner, Lee, Katz, Frost, and Shaywitz, et al. (2001) were the first to document a critical hemispheric shift from right to left hemisphere processing in nonimpaired readers (NI) and reduced activation in disabled readers (RD) with fMRI. Using a set of hierarchically structured tasks that varied the kind of language-relevant coding required they found differences between RD and NI readers in the patterns of activation of several critical components of the LH posterior reading system: posterior STG (Wernicke's area), angular gyrus, occipito-temporal areas and striate cortex. NI readers showed systematic increase in activation as orthographic-to-phonologic processing demands increased, while RD readers did not increase activation in the LH posterior system in response to task difficulty. Rather RD readers demonstrated greater activation in the bihemispheric inferior frontal gyrus (IFG), as well as RH temporo-parietal areas, in response to increasing phonological demands, reflecting not only the greater effort required to perform the task, specifically phonological assembly, but also a compensatory shift to reliance on articulatory recoding (covert pronunciation) to cope . These findings suggest that the RD reader fails to develop a structured temporo-parietal system that can decode effectively resulting in a failure to establish adequate linkages between phonology, orthography, and meaning. Since the temporo-parietal system does not develop normally, the highly integrated word form system in the ventral LH occipito-temporal area fails to develop resulting in the shift to inferior frontal sites and persistent reading difficulties.

Fluency

As a persistent component of reading disability, the behavioral and neurobiological mechanisms that influence fluency are even less understood than the features of dyslexia. Allington (1983) observed that fluency, especially that involving reading connected-text, is the reading skill most neglected in dyslexia research. The neurobiological origins of fluency can actually be seen in the early work of physiologist, Donald Hebb. In 1949, he proposed the concept of unitization when he observed patterns of cells in the visual cortex activating together after multiple exposures to novel visual stimuli. LaBerge and Samuels (1974) went on to apply this idea to more complex visual levels such as familiar letter patterns, and in other modalities such as phonological representations. They focused on the automaticity of processing that decrease response time in learning and reading and is believed to increase the neurological resources allocated to comprehension.

Educators have long used fluency as a measure of reading performance and a sign of superior comprehension, but have not been able to prescribe instructional practices that improve reading speed for all children, especially those with specific reading disabilities. Students were expected to read fluently as a function of age and maturity, and the common preoccupation with measuring fluency as the rate and accuracy of oral reading ignores the multiple other dimensions of fluency, particularly the contributions of lower level subskills: graphological features of letters, orthographic regularities of letter combinations, the semantic features of words, and the semantic-syntactic constraints of word sequences, investigated first by Doehring (1976).

Finally, Kame'enui, Simmons, Good, and Harn (2000) proposed a developmental conceptualization of fluency that included the building of proficiency in underlying component skills of reading, such as phoneme awareness, effectively merging the influences of skill development with processing speed and accuracy into a continuum of reading proficiency. It is this continuum that Wolf and Katzir-Cohen refer to in their comprehensive definition of fluency:

"In its beginnings, reading fluency is the product of the initial development of accuracy and the subsequent development of automaticity in underlying sublexical process, lexical processes, and their integration in single-word reading and connected text. These include perceptual, phonological, orthographic, and morphological processes at the letter, letter-

> pattern, and word levels, as well as semantic and syntactic processes at the word level and the connected text level. After it is fully developed, reading fluency refers to a level of accuracy and rate where decoding is relatively effortless; where oral reading is smooth and accurate with correct prosody; and where attention can be allocated to comprehension." (2001)

Since the development of reading fluency depends on every process and skill used in reading, Kame'enui (2007) proposes that it also requires an increase in accuracy and proficiency in every underlying component. It would follow that failure to acquire these processes and skills could result in serious and persistent reading dysfunctions.

Fluency-Behavioral to Neurobiological Evidence.

Although limited, scientific investigation of fast processing includes not only behavioral data but results from many new technologies as well. The component-based definition of fluency provides the theoretical framework for investigating how the relative contributions of letter-sound association, phonological awareness, orthographic pattern recognition, comprehension, and rapid letter naming impact fluent word and connected text reading in children with the characteristics of dyslexia. Using multi-variant analysis of the results of a battery of reading skills measures of 123 dyslexic 2nd and 3rd graders, Katzir, Kim, Wolf, O'Brien, Kennedy, et al. (2006) found that rapid naming, orthographic pattern recognition, and word reading fluency moderately predicted different dimensions of connected-text reading (i.e., rate, accuracy, and comprehension) whereas phonological awareness contributed only to the comprehension dimension of connected-text reading, when controlling for the children's gender, age, SES, and IQ. The unexpected finding that rapid naming was more related to reading speed than phonological awareness may help explain the limited success of phonology-based reading intervention programs for achieving improvements in fluency and comprehension.

Misra, Katzir, Wolf, and Poldrack (2004) used fMRI to investigate this rapid naming phenomenon more closely by looking at the activation patterns elicited by serial letter rapid automatized naming (RAN) tasks and object RAN tasks. Results from both letter and object naming scans, when compared to fixation, indicated significant activations within all three systems of the reading network: the frontal areas, bilaterally along the ventral visual pathway, and in LH dorsal posterior regions. However, areas that were differentially activated were more active during the letter naming task, especially the angular gyrus (important for the interpretation of orthographic symbols) and superior parietal lobule, underscoring the conclusion that RAN of letters activates many of the same regions and pathways as used when reading words and is, therefore, of greater predictive ability to reading fluency than object RAN tasks.

Functional Magnetic Resonance Imaging

Functional magnetic resonance imaging belongs to a class of research techniques that creates images or maps, actually, of the functional organization of the brain. Unlike most structural MRI, which measures differences between tissues, most functional MRI studies measure changes in the blood oxygenation of the brain over time (Huettel, Song, & McCarthy, 2004). The fundamental concept underlying image formation in MRI is that of the magnetic gradient and its effects on the magnetic properties of water molecules which reflect the influence of paramagnetic deoxyhemoglobin. Changes in deoxyhemoglobin have been shown to be a physiological correlate of oxygen consumption, and these fluctuations are correlated to a change in neuronal activity evoked by sensory, motor, and/or cognitive processes. This is the blood-oxygenation-level-dependent (BOLD) contrast or the difference in signal on T_2^*-weighted images that are commonly used in fMRI studies. The time constant, T_2^*, is the combined effect of transverse relaxation caused by spin-spin interaction (T_2) and changes in spin precession frequency of atomic particles in selected brain tissues due to inhomogeneities in the magnetic field as the transverse magnetization weakens. This effect is best provided by radio frequency pulse sequences with a long repetition time (TR), the time interval between successive excitation pulses expressed in seconds, and medium echo time (TE), the time interval between an excitation pulse and data acquisition usually expressed in milliseconds.

Collecting the MR signal is often referred to as filling *k*-space, a notation scheme which provides mathematical and conceptual advantages for describing the acquired MR signal in image form (Huettel, Song, & McCarthy, 2004). By manipulating the gradient waveforms, the sampling path within *k*-space is controlled during MR signal acquisition. 2-D spatial encoding requires the inclusion of the time integral of the G_z gradient, which combines slice selection and an excitation pulse, in sequence with the G_y gradient, which selects one line of *k*-space following each excitation pulse, and G_x gradient, which is turned on during data acquisition, in the gradient-echo sequence. *K*-space and image space are 2-D Fourier transforms of each other, so after *k*-space is filled a 2-D inverse Fourier transform is necessary for conversion of the raw data from *k*-space to image space. Field of view (FOV) is the total spatial extent along a dimension of image space and it has an inverse relation with resolution when applied to image space and *k*-space. Typical fields of view in fMRI experiments are about 20-24 cm.

The data resulting from fMRI technology is widely accepted as providing reliable and accurate spatial resolution (Huettel, Song, & McCarthy, 2004). It was chosen for this research for the opportunity to confirm interactions between known reading processing subsystems and to begin to lay the foundation for the investigation of developing automaticity as a component of these subsystems. While other technologies may provide more accessible time resolution, Menon, Luknowsky, and Gati (1998) found that even though the microvascular response to the onset of neural activity is delayed consistently by several seconds, the relative timing between the onset of the MRI responses in different brain areas appears to be preserved. The ability to correlate psycho-physical parameters such as reaction time with latency resolved fMRI allows the determination of which neural substrates are involved in task-related processing and which ones are constants of the task. Their results suggest that by focusing on the onset of vascular response, the sequence of neural events during complex functional and cognitive tasks may be revealed using even high spatial resolution techniques such as fMRI. This work indicates then that determining the sequence of ROI activation among the three core reading subsystems may be possible by examining the initiation of activation relative to the stimulus onset of the phonological analysis tasks.

Intervention and Developmental Effects

Several post-intervention studies show different patterns of activation in the reading networks, evidence of the strength of experimental results in suggesting effective neurobiologically-based remedial instructional practices. Shaywitz, Shaywitz, Blachman, Pugh, Fulbright, Skudlarski, et al. (2004) found increased LH activation of IFG and the middle temporal gyrus only in children with the characteristics of dyslexia who participated in daily tutoring of the alphabetic principle and phonological processing and not in those children who participated in a variety of common reading interventions exclusive of explicit phonology. Their longitudinal data also indicated a continuation of correct activation patterns one year past, suggesting the durable nature of the processing change.

Similarly, Simos, Breier, Fletcher, Bergman, and Papanicolaou (2005) using MSI found that after 80 hours of intensive phonological intervention, dyslexic children showed a dramatic increase in the activation of left temporo-parietal regions, predominately in the left posterior STG, the network that supports grapheme-phoneme recoding in typical developing readers. However, even after intervention, neural activity was delayed in the dyslexic children relative to the controls (837 ms on average for dyslexics and 600 ms for controls), indicating that even with intensive phonological remediation, dyslexic children are slower to achieve the same reading fluency shown by non-dyslexic children. Further, high-risk children, who were nonresponsive to the phonological remediation package that was being offered, were distinct in showing earlier onset of activity in IFG compared to the temporo-parietal regions. This would indicate a persistent processing anomaly that influences ineffective decoding as well as decreased processing speed.

Unexpected challenges arise from the documentation of natural hemispheric and regional subsystem shifts in reading behavior that must be considered in evaluating neurobiological data. Licht, Bakker, Kok, and Bouma (1988) used event related potentials (ERPs) related to word naming over a four year longitudinal study and found that most children shift the processing of words from the right hemisphere to the left by the end of grade 1, beginning of grade 2 (age 6-7 years). This was the first evidence of a long-suspected major change in brain regions for the developmental processing of written language.

Shaywitz, Shaywitz, Pugh, et al. (2002) found another naturally occurring developmental shift in activation of the three cortical reading subsystems that occurs slightly later, around grade 4 (age 10 ½ years). They observed that younger children, non-impaired readers (NI), showed stronger engagement of the dorsal temporo-parietal system: including the angular gyrus, supramarginal gyrus (SMG) in the inferior parietal lobule and posterior aspect of the superior temporal gyrus (STG or Wernicke's area); and the anterior system: posterior aspect of the inferior frontal gyrus (IFG); but limited use of the ventral system: LH inferior occipito-temporal/fusiform area, extending anteriorly into the middle and inferior temporal gyri (MTG and ITG, respectively). In contrast, children (NI) older than 10 ½ years of age showed increased engagement of the ventral system, which is associated with increasingly skilled reading, i.e. positively correlated with higher reading scores. These results would seem to support the suggestion offered by Pugh, Mencl, Jenner, Lee, and Latz, et al., (2001) and Sandak, Mencl, Frost, and Pugh, et al., (2004) that this ventral system fails to develop in students with the characteristics of dyslexia, not because of impairment but as a result of lack of proper stimulation. This exploratory study intends to look for evidence of fluent processing that could include both of these naturally-occurring processing shifts in reading development.

Methodology

Sample

Twenty students, five females and 15 males, ranging in age from 8 to 19 years, were recruited from three private schools in a large urban setting. All of the families self-selected their student's participation in the study by returning a Release of Confidentiality after attending an informational meeting or receiving a letter of introduction from their child's school administrator. Each family was visited by the PI to discuss in detail MRI safety information and answer any questions about the research or intervention. As a result of these visits, two students were found to be unsuitable for fMRI imaging and agreed to withdraw from the study. (See Table 1)

Table 1

Subject Demographics

Subject Code	Gender	Age	Reading Instructional Level	Group Assignment
CB	F	8 yrs.	gr.1	Delayed Intervention
CC	F	10 yrs.	gr. 4	Delayed Intervention
PA	F	11 yrs.	gr. 4	Delayed Intervention
PC	M	8 yrs.	gr. 2	Intervention
PE	M	10 yrs.	gr. 4	Intervention
MA	M	16 yrs.	gr. 7	Intervention
MC	M	16 yrs.	gr. 4	Intervention
MD	F	16 yrs.	Primer-3	Intervention
ME	M	17 yrs.	gr. 3	Intervention
MF	M	15 yrs.	gr. 8	Intervention
MG	M	14 yrs.	gr. 5	Delayed Intervention
MI	M	16 yrs.	gr. 6	Intervention
MJ	M	19 yrs.	gr. 8	Delayed Intervention
ML	F	16 yrs.	gr. 2	Delayed Intervention
MN	M	19 yrs.	gr. 10	Intervention
Summary:	M = 10 F = 5	Range: 8-19 yrs Mode: 16 yrs Ave: 14 yrs	Range: Pr3-gr. 10 Mode: gr. 4 Ave: gr. 5	Intervention Group = 9 Delayed Intervention Group = 6

Analysis of standardized test results showed that all of the rest of the students, except for two, qualified as students with the characteristics of developmental dyslexia according to ICD-10 criteria (WHO, 1992) which was used by Lorusso et al. to identify their subjects. This criteria was interpreted for this study as performance on a standardized assessment of text reading that is reflected in a scale score of 600 or below in at least one of the tests for speed and accuracy in reading and/or spelling, despite an average IQ, as assured by each school administrator. (See Table 2) Stanford Achievement Test documents state that scale scores below 600 indicate “non-mastery” of skills. When scale scores were not available, percentile measurements of 50% or lower were used to show lack of reading proficiency.

Table 2

Standardized Testing and Intervention Program Assignment Justification

Subject Code	Standardized Test, grade level, year, subtest and SS/%tile	Analysis of Errors – RR and level	Justification for Program Assignment	Dyslexia Sub-type	Recom-mended Program
CB	Stanford gr. 1 2010 Word Rdg. = 481	Pr./ 50 wpm No errors	Slow processing; good comp.	Mixed	LH/RH
CC	Stanford gr. 4 2010 Rdg. Comp. = 627	gr. 4/ 128 wpm No errors	Reports using meaning to decode unknown words	L-type	RH
PA	Stanford gr. 4 2010 Total Rdg. = 581	gr. 2/ 92 wpm 2 errors	Both errors were meaning-based	L-type	RH
PC	Out of state gr.2 2010 Visual processing/Rdg.	gr. 3/ 78 wpm No errors	General skill level and personality type	L-type	RH
PE	Stanford gr.4 2010 Total Rdg. = 508	gr. 1/40 wpm 6 errors	5 errors were phonics-based	P-type	LH
MA	Stanford gr. 7 2010 Rdg. Comp. = 688	gr. 7/ 53 wpm 4 errors	All errors were meaning-based; slow processing	Mixed	RH/LH
MC	Stanford gr. 4 2010 Word Study = 578	gr. 4/ 69 wpm 3 errors	All errors were phonics-based	P-type	LH
MD	Stanford Pr3 2010 Rdg. Vocab. = 45%tile	gr. 3/ 87 wpm 8 errors	5 errors were phonics; 3 errors were meaning-based	Mixed	LH/RH
ME	Stanford gr.3 2010 Word Study = 544	gr. 2/ 54 wpm 6 errors	All errors were meaning-based	L-type	RH
MF	Stanford gr. 8 2010 Rdg. Comp. = 662	gr. 8/102 wpm No errors	Slow processing	P-type	LH
MG	Stanford gr. 5 2010 Spelling < 12%tile	gr. 4/ 48 wpm 5 errors	All errors were meaning based	L-type	RH
MI	Stanford gr. 6 2010 Word Study = 605	gr. 5/106 wpm 4 errors	Three of the errors were meaning; one error was phonics-based	Mixed	RH/LH
MJ	Stanford gr. 8 2010 Rdg. Comp. < 8%tile	gr.8/98 wpm 3 errors	Errors were different; personality type	L-type	RH
ML	Stanford gr. 2 2010 Word Study < 6%tile	gr. 1/ 70 wpm 5 errors	4 of the errors were meaning-based	L-type	RH
MN	Stanford gr. 10 2010 Vocabulary - 703	gr. 8/115 wpm 5 errors	All errors were phonics-based	P-type	LH

Additionally, pre-intervention fluency assessment scores were used to subtype the students with the characteristics of dyslexia. All subjects were classified as P-, L-, or M-dyslexics on the basis of their reading speed and reading errors (“time-consuming errors” such as fragmentations and repetitions or “substantive errors” such as substitutions and omissions) according to the following formula based on Lorusso, et al. (2006):

1. P-type, if reading speed is at least 1 SD below age mean (i.e. $z < -1$) and the proportion of time-consuming errors over total errors is ≥ 60%.

2. L- type, if reading speed is no more than 1 SD below age mean (i.e. $z \geq -1$) and the proportion of substantive errors over total errors is ≥ 60%.

3. M- type in all other cases (prevalence of time-consuming errors but reading speed above -1 SD; prevalence of substantive errors but speed below -1 SD; presence of an equivalent amount of both kinds of errors).

The process of using these subtypes to match the optimal hemisphere-specific stimulation to each student for remediation purposes required some modifications to accommodate different kinds of reading errors found in English readers. (See Table 2) In addition to the “substantive” errors as described by Bakker et al. (2001), some readers of English tend to create meaning based on their experiences and vocabulary. These fabrications tend to have little to do with what is printed on the page, but make perfect sense when lifted from the printed text. Students who committed these kinds of errors were considered L-type since they were using the context of the sentence to produce meaningful, though wrong, substitutions and were given the Right Hemisphere Intervention program. All students provided baseline fluency scores and end-of-study fluency scores through their regular classroom assessments when possible.

Also, the remaining sixteen students with the characteristics of dyslexia were randomly assigned to either the Intervention condition or the Delayed Intervention condition. Nine of the students in the Intervention condition completed 1440 minutes (24 hours) of the recommended version of the FlashWord computer program during the spring semester of the 2010-2011 school year. One student refused to participate and was withdrawn from the study. Six students in the Delayed Intervention group participated in the usual reading fluency program at their school and only used the FlashWord computer program after the second scan. All students participated in the two fMRI scans and statistical analysis, so the Delayed Intervention group represents a true comparison of the VHSS treatment effects on this target population.

To execute a true replication of Lorusso et al. (2006), it was expected that a non-impaired control group would be created. This control group would have participated in whatever reading fluency program their school was using and by contributing their Mid-Year and End-of-Year fluency scores from their regular classroom reading assessments to the study, would have provided a comparison of the traditional evaluation groups: Reading Disabled vs. Non-Impaired Readers. However, these matched records proved to be very difficult to locate due to the ages of several of the participants and unfortunately will not be a part of the statistical analysis.

Experimental Design

This fMRI experiment uses a mixed design, in that the events of interest are randomized with perceptual controls to provide robust event-related activation maps and estimates of hemodynamic response. Burock, Buckner, Woldorff, Rosen, and Dale (1998) show that using fixed intertrial interval designs decreased the amount of transient information as the intertrial interval decreased, while randomized designs using the same mean intertrial interval increased the amount of briefly present information even at shorter intervals. The word pairs (phonological analysis) and letter match (perceptual control) stimuli in this study are randomly presented every 12- 18 seconds within each run. These data will include not only the activation from the phonological subsystems but also from the perceptual system, motor cortex, and visual cortex. The perceptual control and fixation conditions, as well as the effects from the visual presentation and motor response will be constant across the scan and will therefore cancel out. Comparison of the Word Pairs task over the Letter Match task should isolate the phoneme-mapping processes and the associated brain regions uniquely involved in phonological analysis apart from letter processing alone.

Procedures

As part of the recruitment process, each family who expressed interest in the study was interviewed by the primary investigator to answer questions confidentially and ascertain their child's physical qualifications for participating in the fMRI procedures before formally submitting application to the lab. Research shows that the greater the level of education a family has regarding the fMRI process, the more likely the child will be successful in the MR environment and produce useful data (Byars, et al., 2002). Familiarizing the family and the child with the sounds that the scanner makes and the equipment they will be using is important to the child's comfort level and participation in the fMRI environment.

Using appointment times provided by the lab, the PI met the students and their families at the Baylor College of Medicine Human Neuroimaging Lab for their fMRI scans. Clearance from security had to be obtained for each subject due to their ages. Before the scan, the students were thoroughly trained on the word pairs task and the letter matching task, they were asked to do in the scanner, to increase the likelihood that they would be able to respond appropriately to the stimulus. They tried on the earphones which were worn for the experiment and several subjects practiced putting the “phantom head” into the scanner to reduce anxiety. This was also the time for the parents and students to sign the University of Houston Informed Consent forms, reaffirming that the researcher would be in contact with the subject through the headphones throughout the course of the experiment and that at any time the experiment can be discontinued with no consequences.

Following the pre-intervention scanning session, the students in the Intervention condition participated in the computerized visual hemisphere-specific stimulation program, FlashWord, modified, according to their dyslexia subtype at their school. Each school adopted their own schedule for intervention and volunteers generally administered the program after training from the PI. The PI maintained weekly communication with the volunteers and students, updating and scoring each student’s Intervention binder and meeting with volunteers to make sure that minimum competencies were being met as the processing time was being decreased. (See Appendix A) Finally, all of the students with the characteristics of dyslexia returned for the post-intervention scanning session using the exact same design, task, and procedures as before. Care was also taken to ensure that students, post-intervention, were scanned in the same machine as they were for the pre-intervention scan.

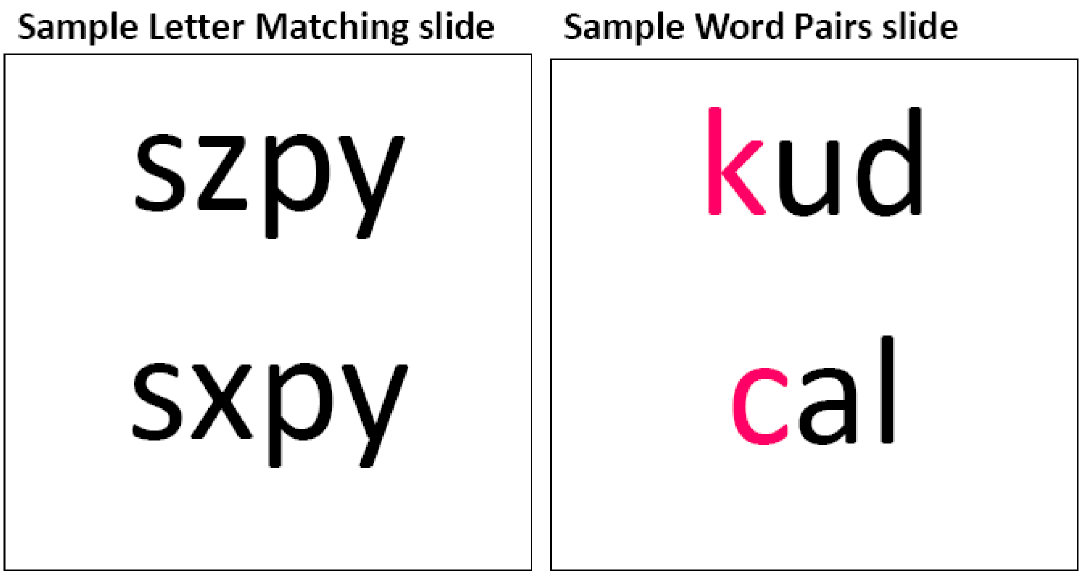
Treatments

Stimulus Description- Scanner Task.

The letter match task requires the child to decide whether two letter strings (e.g., *szpy* and *sxpy*) printed in all black letters and presented simultaneously one above the other matched exactly. Length of the letter strings is comparable to the length of the pseudowords used in the phonological analysis task. This control task requires attention to all letter positions but does not involve assigning speech sounds to letters. The child will be directed to press a button, “Yes”, if the letter strings match, or to press a different button, “No”, if the letter strings do not match. For the phonological task condition, the word pairs will be decodable non-words printed in black, each containing a letter or group of letters printed in pink, also presented visually, one above the other. (See Figure 1) The child will be directed to press the button “Yes”, if the pink letter(s) in the top word could stand for the same sound as the pink letter(s) in the bottom word, and to press a different button “No”, if the pink letters stand for different sounds. All responses must occur within the 12-18 s duration of a slide in order to be recorded.

Figure 1

Sample Visual Stimuli



During the fMRI scanning, there were 116 total slides randomly presented to each subject; 60% (69) showing word pairs and 40% (47) showing letter matches. Slides with the letter match stimulus appeared for 12 s and slides showing word pairs were presented for 18 s for a total functional scanning time of 27 min./subject. (See Figure 2) One-half of each of the task condition slides will be yes. All words and letters will be presented at the center of the screen printed in black (or pink) Calibri lower-case letters large enough to be easily seen.

Figure 2

Task Parameters

Fixation Word Pair Letter Match Letter Match Word Pair Word Pair Letter Match

(BP) (BP) (BP) (BP) (BP) (BP) (BP)

8s 18s 12s 12s 18s 18s 12s

Intervention.

FlashWord, Ver. 2.2, written by Franco Fabbro and Cristina Masutto (copyright, 1995-2004 by Editrice TecnoScuola) and used for this research by permission, is a computer program that uses a game-format to present words or phrases in the right or left visual hemi-field at increasingly rapid rates. Rates of 250-100 ms are generally considered to reflect "emerging fluency" (Bakker, et al., 1990). The student sees the words or phrases projected on either the right or left side of the computer screen, stimulating either the right or left visual field and the opposite brain hemisphere, according to their dyslexia sub-type. Ocular fixation is monitored by asking the child to follow a luminous dot oscillating up and down on the screen at an adjustable speed. A word is flashed only if the child clicks on the mouse at the exact moment the dot is crossing the central target. The child's task is to read the words as they are flashed on the screen.

The word lists created for the English version of FlashWord were modeled on the Italian word lists following general guidelines from the authors. The Left Hemisphere Program word lists were structured to mirror traditional reading instruction sequences: short vowel patterns, long vowel silent "e" patterns, regular vowel and consonant patterns, suffixes, irregular vowel and consonant patterns, vowel-r patterns, diphthongs, final stable syllables, and prefixes. The words themselves were generated from lists of words for teachers like The Yellow Pages for Students and Teachers (Kid's Stuff People, 1980) and Cypress-Fairbank's Dyslexia Handbook published by Region IV Education Service Center in Texas. The phrases were found in Fry's Instant Phrases (available on the internet) and the Dyslexia Handbook. To create the Right Hemisphere Program, nonsense words and phrases were formed following the structure of the left hemisphere lists. Additional lists of related words are original, while high image value words, words that tend to be memorized instead of phonologically decoded, were selected from Fry's 600.

Before the beginning of each lesson with the student, criteria for word presentation are set, including target speed and tolerance, and presentation times: which may start as slow as 1000 ms for words and 2000 ms for phrases. Students using the Right Hemisphere program also get to choose the colors of the words and background and the font displayed. The longest presentation times were used in the first sessions, initially so that the child was able to read the word list with at least 70% accuracy, and later when more complex stimuli are presented for the first time. As the child's reading performance improves, presentation times will be shortened in the following sessions, so as to keep pressure on the system of word recognition. The lists of 25-80 words/phrases become increasingly more difficult in terms of word length and complexity, so that final lists also include short sentences selected according to familiarity and predictability. In order to further stimulate anticipation in P-types, there will be progressive shortening of presentation times within the same session, and to encourage precise decoding in L-types, uncommon font types will be used. (See Appendix A)

Each intervention site provided its own monitors. Administrators, parents, graduate students, and even alumni were effective at mastering the lesson set-up for each of the programs and keeping track of the students' responses after initial training by the PI. Most schools were able to schedule individual students to work with the intervention daily from 30-45 min. Schools with greater numbers of participants required a reciprocally greater commitment to following through to complete the intervention, which became more difficult as the semester drew to an end. As a result, there were several students at one facility who had nearly half of the program to complete when the school year ended. Only through individual appointments conducted during a two-week period following the cessation of regular classes, did these students complete the entire intervention program. (See Appendix B) While this treatment delivery system was not ideal, it is not anticipated that the differences in the administration of the intervention will affect the student outcomes. There were also differences in the scheduling and duration of the intervention sessions as compared to the Lorusso et al. study which are not believed to have influenced the results.

Acquisition of MRI and fMRI scans

Structural and functional MR imaging was performed on one of two Siemens head-only 3T Allegra Magnetic Resonance scanner. Scanning included a 192 transversial slice, high-resolution set of anatomical images in plane with functional data (TR/TE 1200/2.93 ms; fast spoiled gradient echo pulse sequence; 0.96 x 0.96 x 0.89 mm; 256 x 208 matrix). This anatomical series was followed by four fMRI series using two-dimensional gradient echo echoplanar pulse sequence (TR/TE 2000/50 ms, 26 transversial slices; at 4 mm with 0% overlap, 64 x 64 matrix. Total MRI scan will last approximately 32 minutes 10 seconds. Children viewed the stimulus on a rear-projection video display (NEC GT2150) using mirrored lens attached to the head coil. If a student required glasses to see the stimulus clearly, MR-compatible frames with insertable polycarbonate lenses (Solo Bambini) were created. Participants indicated their responses on two, two-button optical response pads (Current Designs, Inc.), one held in each hand.

Most of the students allowed the PI to mark on their thumb “Y” or “N” to help them remember. They indicated a “Yes” or “No” response by pressing a certain button within the 12-18 s stimulus presentation in order to be counted as correct. These responses were monitored during scanning to ensure that the subject was awake and on task.

fMRI Image and Data Analysis.

Initially the fMRI data was visually analyzed to assess the amount of movement and its effect on the quality of the activation maps. Preprocessing of the data included slice timing correction to mathematically reconcile imaging differences, co-registration to a standard brain to align the images, and correction of severe head motion to improve activation detection. Normalization was used to create group data, spatial smoothing was done using a 3 mm blurring filter and temporal filtering is important for reliably identifying voxels that are firing at the same time, possibly indicating their connectivity. Due to a large amount of movement during some of the scans, it was also necessary to remove from estimation those images that were produced while parameters exceeded the acceptable range. This was especially important when processing images for a case study of various subject conditions.

At the first level of analysis, the pre-processed fMRI images, the stimulus onset times (SOTs) for each condition, and the six movement parameters are correlated to create a design matrix of the data. This model is estimated and four contrasts were created: the Letter Match condition (showing activation, a correlation coefficient at each voxel of the brain, for only the letter match stimuli), the Word Pairs condition (showing activation from only the word pairs stimuli), Letter Match greater than Word Pairs condition (showing activation from the letter match stimuli that surpassed the activation from the word pairs stimuli), and Word Pairs greater than Letter Match condition (showing activation from the word pairs stimuli that surpassed the activation from the letter match stimuli).

The average activation of MR signal for each ROI is determined using cluster-size thresholding, a technique where data is analyzed using a relatively liberal alpha value (e.g., $P < 0.1$) for voxel-wise comparisons. The conservatism of the test is increased by only counting clusters as significant if they are as large as some threshold. Typical cluster-size thresholds for fMRI data are around three to six voxels. These clusters will be identified within the three core reading subsystems, the Anterior Processing system in the IFG, the Temporal-parietal system in the STG and MTG, and the Occipital-temporal system in the VWFA. Since these regions have already been identified as collaborative areas that produce particular reading behaviors, the challenge of creating these homogenous and indivisible units is greatly reduced.

This experiment evaluates the influence of the core reading subsystems (the occipital-temporal, temporal-parietal, and anterior activation sites based on previous research) and other sources of variability (nuisance factors or error) on fluency and accuracy using multiple linear regression. This analysis should reveal the relative influence of each of the core reading subsystems on the development of fluency.

Results

Behavioral data

Pre-intervention scores collected in January and post-intervention fluency scores gathered in May or June were examined by subject and by group to determine ranges of net gain and average gain. (See Table 3) Subjects in the Intervention group (N = 9) produced pre-intervention scores ranging from 40-115 wpm (average score was 78 wpm) and post-intervention scores ranging from 51-131 wpm (average- 90 wpm). Subjects in the Delayed Intervention group (N = 6) had pre-intervention scores ranging from 24-128 wpm (average score was 77 wpm) and post-intervention scores ranging from 50-120 wpm (average- 85 wpm). The net gain over this six month period demonstrated by the Intervention group was 11.9 wpm and for the Delayed Intervention group was 7.3 wpm. Two subjects in the Intervention group and one in the Delayed Intervention group actually produced slower post-intervention scores as compared to their pre-intervention assessment. Also, one subject in each group showed an increase of only one word-per-minute, so the averages mask some substantial gains made by some students in both groups.

Table 3

Fluency Summary

Subject Code	Pre-intervention scores	Program/ lowest speed: words-phrases	Reached fluency? (100-250 ms)	Post-intervention scores	Difference
CB	24 wpm/gr. 2	LH	DI	50 wpm/ gr. 2	26 wpm
CC	128 wpm/gr. 4	RH	DI	120 wpm/ gr. 5	-8 wpm
PA	92 wpm/ gr. 2	RH	DI	116 wpm/ gr. 3	14 wpm
PC	78 wpm/gr. 3	RH/75-125	Yes	120 wpm/gr. 4	42 wpm
PE	40 wpm/gr. 1	LH/150-200	Yes for words	51 wpm/ gr. 1.5	11 wpm
MA	53 wpm/ gr.7	RH/250-700 LH/80-150	No Yes	63 wpm/ gr. 8	10 wpm
MC	69 wpm/ gr. 4	LH/80-80	Yes	95 wpm/gr. 4.5	26 wpm
MD	87 wpm/ gr. 3	LH/500-700 RH/300-400	No No	75 wpm/ gr.3.5	-12 wpm
ME	54 wpm/ gr. 2	RH/400-1000	No	55 wpm/gr. 3	1 wpm
MF	102 wpm/ gr. 8	LH/70-80	Yes	118 wpm/gr. 8	16 wpm
MG	48 wpm/ gr. 4	RH	DI	52 wpm/ gr. 4	6 wpm
MI	106 wpm/ gr. 5	RH/200-500 LH/70-500	No Yes for words	103 wpm/ gr. 6	-3 wpm
MJ	98 wpm/gr. 8	RH	DI	103 wpm/gr.8	5 wpm
ML	70 wpm/ gr. 1	RH	DI	71 wpm/ gr. 1	1 wpm
MN	115 wpm/ gr.8	LH/40-80	Yes	131 wpm/ gr. 8	16 wpm

A paired-samples t-test compared pre-intervention fluency scores with post-intervention scores for subjects in both Intervention and Delayed Intervention groups. The correlation (.879) of these scores was significant ($p < .001$) indicating a strong relationship between the scores. The t-test for the paired samples was also significant, $t(14) = -2.81$, $p < .05$ indicating that there are differences between the reading fluency scores of the students in both groups. Looking at just the relationship of those subjects in the Delayed Intervention group and their pre- and post-intervention fluency scores, a very high significant correlation (.94, $p < .01$) was noted but no significant difference was found between pre-intervention fluency ($M = 76.67$, $SD = 37.32$) and post-intervention fluency ($M = 85.33$, $SD = 31.68$). Examining the relationship of the Intervention group and their pre- and post-intervention fluency scores revealed another high and significant correlation (.85, $p < .01$) and again, there was no significant difference found between pre-intervention fluency (M = 78.22, SD = 26.31) and post-intervention fluency (M = 90.11, SD = 30.12).

To determine if there was any interaction effect attributable to the intervention, pre- and post-intervention fluency scores were analyzed by means of a 2-way mixed-design ANOVA having two levels of fluency scores, the Intervention and the Delayed Intervention groups as the between-subjects factor and the two assessment points, pre-intervention and post-intervention as the within-subjects factor. The interaction effect of *Fluency score* x *Group* was found not to be statistically significant, $F(1,13) = .04$, $p > .05$, indicating comparability between the two groups' scores (Intervention group- M = 84.17, SE = 9.98, and Delayed Intervention group- M = 81.0, SE = 12.0). The within-subjects main effect of pre- and post-intervention fluency scores was found to be statistically significant, $F(1, 13) = 6.68$, $p< .05$, partial $\eta^2 = .31$. Results showed that the pre- and post- intervention fluency scores for the Intervention and Delayed Intervention groups differed significantly from each other, even though this difference only accounts for about 30% of the variance.

Intervention data

The results of 1440 minutes of intervention quantified in milliseconds and representing a change in speed of processing was used as a measure of achieved fluency in the Intervention group only. This evidence of processing change was analyzed by means of a two-way mixed design ANOVA having two levels of reading fluency scores (pre- and post-intervention) as a within-subjects factor and two levels of fluency: those students (N = 6) who reached levels of emerging fluency, 100 ms or less, and those (N = 3) who did not, as a between-subjects factor. The between-subjects main effect of the fluency rate achieved during intervention was significant, $F(1,8) = 5.38$, $p = .05$, indicating differences between the students who achieved fluent processing as measured through the FlashWord intervention and those who did not.

Statistical analysis of fMRI data

The statistical parametric mapping program (SPM8) was used to analyze the level of activation present measured by t-scores in the ROIs for each subject using the Word Pairs over Letter Match condition which is expected to focus on phonological analysis processing in these areas. The creation of these ROIs was based initially on Talaraich coordinates for the Inferior Frontal Gyrus, Superior Temporal Gyrus and Visual Word Form Area from relevant literature. Individual differences were accommodated by using the highest value from with the identified area. These values were calculated from the post-intervention scans only. (See Table 4)

Table 4

Measured ROI Activation Post-intervention

Subject Code	Group/ Fluent?	LH IFG *t* score	LH STG *t* score	VWFA *t* score
CB	DI/NA	0	0	2.37
CC	DI/NA	2.56	2.40	2.46
PA	DI/NA	0	0	0
PC	I/Yes	0	0	0
PE	I/Yes	2.39	2.39	2.39
MA	I/Yes	2.48	3.36	2.57
MC	I/Yes	2.34	3.9	2.33
MD	I/No	2.34	0	0
ME	I/No	0	0	0
MF	I/Yes	0	0	2.5
MG	DI/NA	0	0	2.65
MI	I/No	3.38	3.10	2.52
MJ	DI/NA	2.51	2.38	2.73
ML	DI/NA	2.67	2.36	0
MN	I/Yes	0	0	2.35

An independent-samples t-test compared the mean activation level captured in *t* scores from voxels in the Inferior Frontal Gyrus (IFG) located generally at Talairach coordinates: -46, 35, 12 for the Word Pairs over the Letter Match condition in the Intervention (M = 1.43, SD = 1.40) and Delayed Intervention (M = 1.29, SD = 1.41) groups. This comparison was not statistically significant, indicating that the level of activation in this region of interest was not different between the two groups of students. Identical analysis of the Superior Temporal Gyrus (STG), and the Visual Word Form Area (VWFA) yielded similar results. In the STG, generally located at Talairach coordinates: -59, -21, 12 for the Word Pairs over Letter Match condition no difference was found for activation levels, Intervention group (M = 1.42, SD = 1.73) and Delayed Intervention group (M = 1.20, SD = 1.31). In the VWFA, generally located at Talairach coordinates: -42, -57, -6 for the same condition no difference was found, Intervention group (M = 1.37, SD = 1.30) and Delayed Intervention group (M = 1.70, SD = 1.32).

The measured levels of activation in the regions of interest, IFG, STG, and VWFA located as previously noted were analyzed by means of a two-way mixed design ANOVA having two levels of achieved fluency (fluent and not fluent). Neither the main effect comparing the means of the brain regions nor the interaction effect of the subject's fluency level on brain activation in these areas was significant ($F < 1.0$).

These results appear to be contradictory to the expected activation until the effects of excessive movement and the variability inherent in the extremely wide range of reading levels are considered. Both Subject PA and Subject PC engaged in excessive mouth movement and their scans revealed very little activation at all, even at the lowest p allowed. Subject ME did not exceed movement parameters, but RH structural damage was apparent in the images and external scarring that could very well affect bilateral processing systems. Other profiles in the Intervention group seem to show various levels of processing. For example, Subject MD appears to still be using a lot of sound/symbol matching to make phonological decisions, as evidenced by activation only in the IFG. After working with both the LH and RH programs, this student did not reach fluency in either and only increased reading speed 8 wpm. Subjects MF and MN both reached fluent levels of processing in the LH Program and increased their reading speed by 16 wpm, so the activation detected only in the VWFA could indicate reliance on the automatic retrieval of letter patterns to conduct the phonological analysis required by the scanner task.

There is also some very strong activation found in the scans from subjects in the Delayed Intervention group. Clearly, even the pre-intervention fluency scores for Subject CC were fairly fast and remained one of the fastest rates compared to the post-intervention scores from the Intervention students. Strong activation was found for Subject MJ, who while reading at a fairly slow rate, knows a lot about the reading system by working at the 8th grade level. This subject is also one of the oldest students and so has a greater amount of exposure to reading over time, which might account for the robust activation in all three ROIs in the absence of working with the intervention. Subject ML is reading at a very slow rate and at a very low level, so the lack of activation in the VWFA could reflect this extreme lack of automaticity in phonological analysis.

It is clear from this data that the creation of group activation maps would not produce reliable information about either group of subjects. For that reason, only activation from representative single subjects will be explored.

Data from fMRI analysis

These activation maps represent the condition of brain activation resulting from the phonological analysis of word pairs over the activation resulting from a perceptual control: the visual matching of strings of non-pronounceable letters, in a sample of subjects. The crosshairs have been positioned over the Inferior Frontal Gyrus (IFG) in each subject for visual comparisons. The calibration maps are generally the same, but could vary somewhat from scan to scan.

Subject 1 was one of the students who reached very fast processing speeds during the intervention using the left hemisphere program, and increased reading speed by 26 wpm. The pre-intervention scan (A) shows mostly diffuse activation in the right hemisphere occipital-parietal areas. The post-intervention scan (B) shows much more focused activation bilaterally in the temporal regions around the Superior Temporal Gyrus and Postcentral Gyrus, and there is very little activation in the VWFA in the LH occipital lobe.

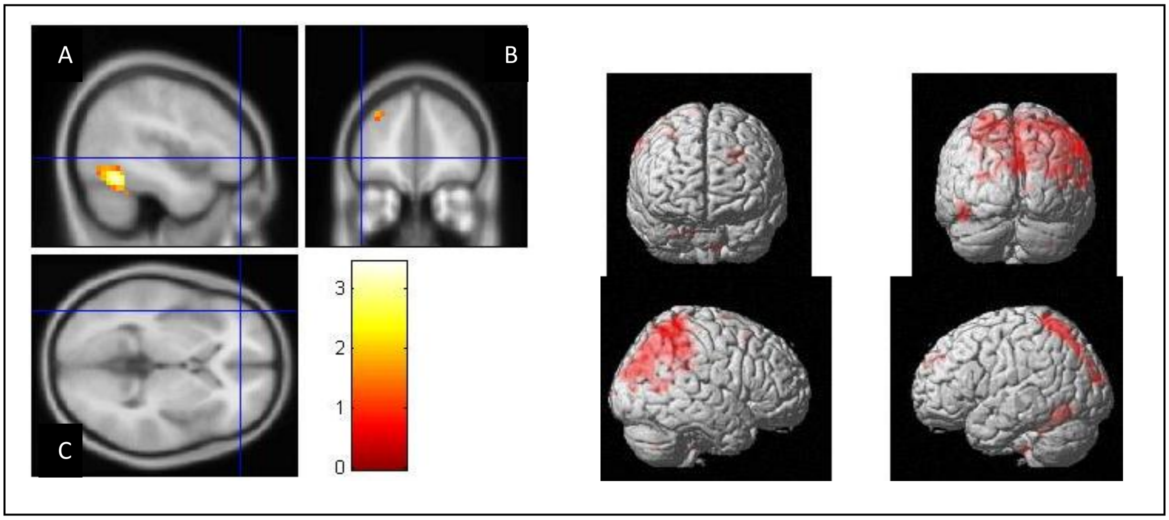
Subject 2 was one of the students who achieved processing speeds that approached fluency using the left hemisphere program, and increased reading speed by 11 wpm. The pre-intervention scan (A) shows a lot of bilateral frontal activation and more RH activation than LH activation in the occipital areas. The post-intervention scan (B) indicates an increase in left hemisphere activation around the IFG and VWFA.

Subject 3 was one of the students who did not reach fluency in either the right or left hemisphere program, and actually read 8 wpm more slowly during the post-intervention fluency assessment than the pre-intervention test. The pre-intervention scan (A) shows only activation in the LH parietal-occipital areas with no activation near the IFG or STG which would indicate basic levels of phonological processing. The post-intervention scan (B) shows an increase in activation in the frontal cortex, with bilaterally diffuse activation evident in phonological processing areas.

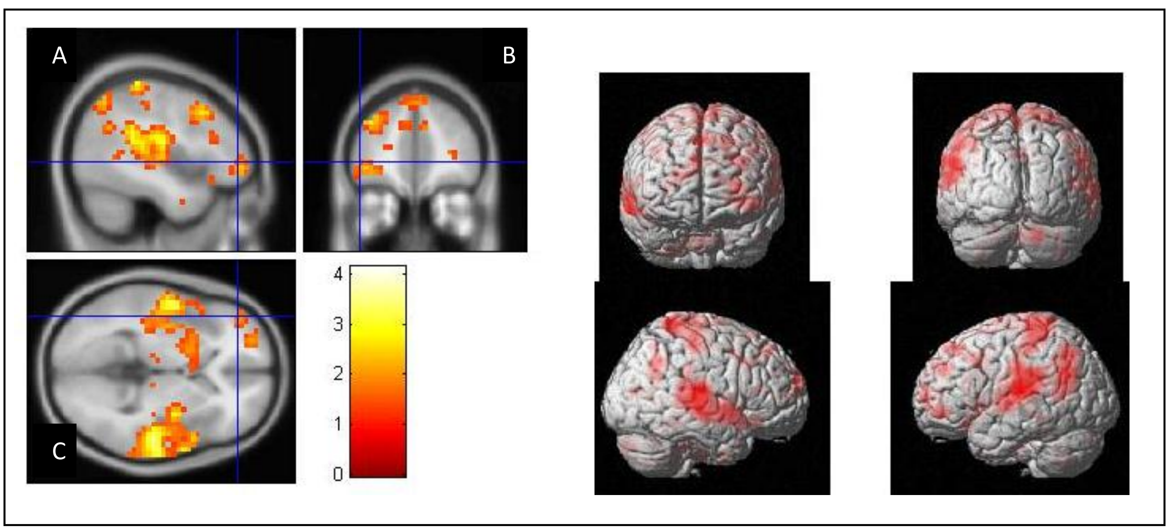
Figure 3

Selected Activation Maps of Subject 1

A. Pre-intervention activation in Subject 1



B. Post-intervention activation in Subject 1

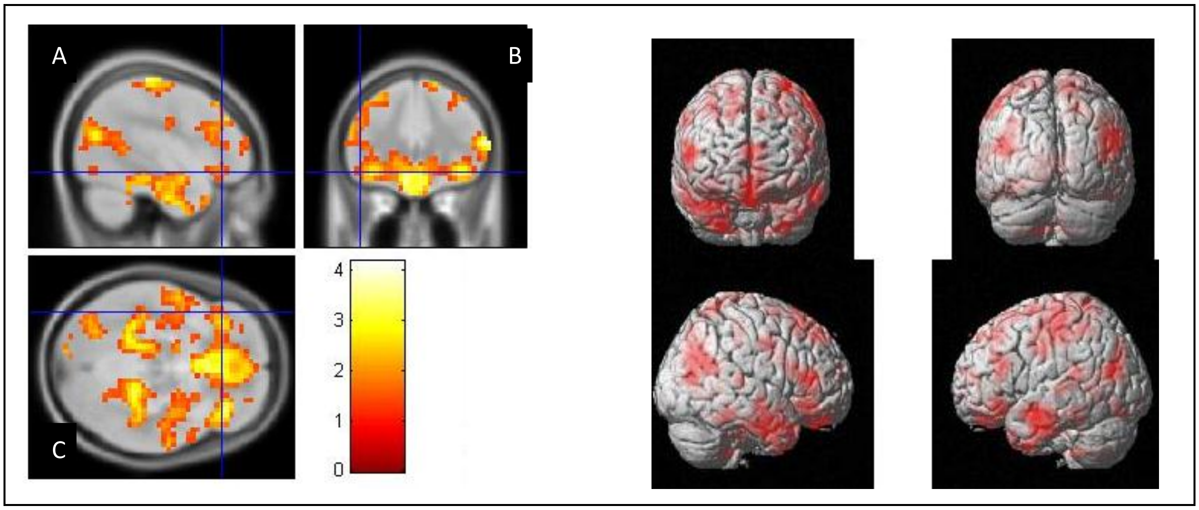


Activation maps from random effects analysis for phonological processing of word pairs greater than perceptual control of letter match condition in Subject 1 at A) pre-intervention and B) post-intervention. Renderings of the significant activations are presented on the frontal and posterior views and the lateral aspect of each hemisphere (the frontal view and the right hemisphere is on the left side of the graphic). Activation slice A shows a saggital view, slice B is a coronal view and slice C, the transverse view , with the crosshairs on IFG in both sets of maps for reference. The calibration bar indicates *t* values for comparison ar each area presented on the slice views.

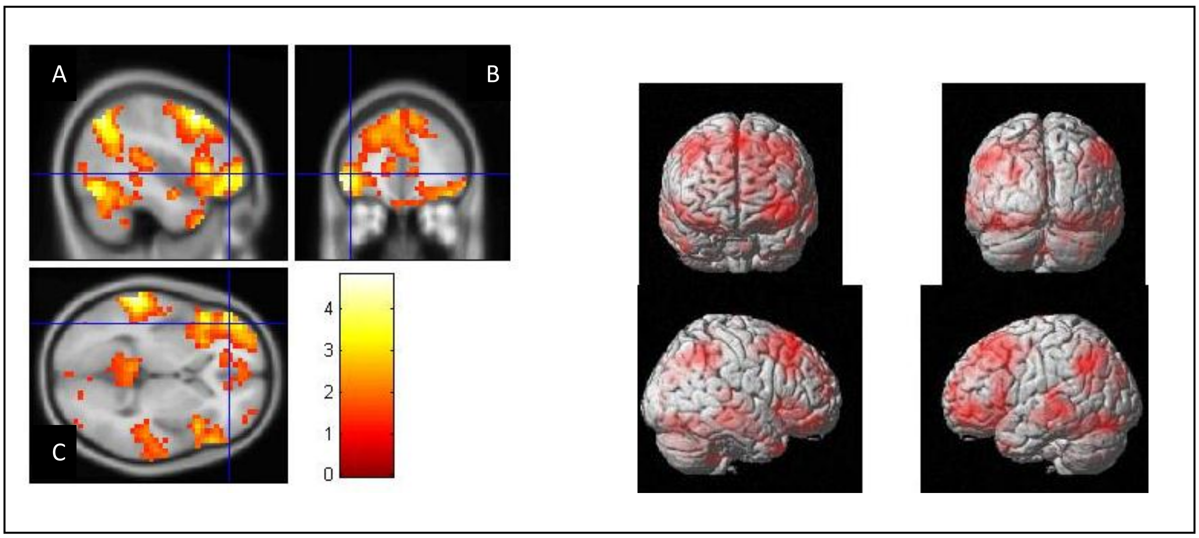
Figure 4

Selected Activation Maps of Subject 2

A. Pre-intervention activation in Subject 2



B. Post-intervention activation in Subject 2

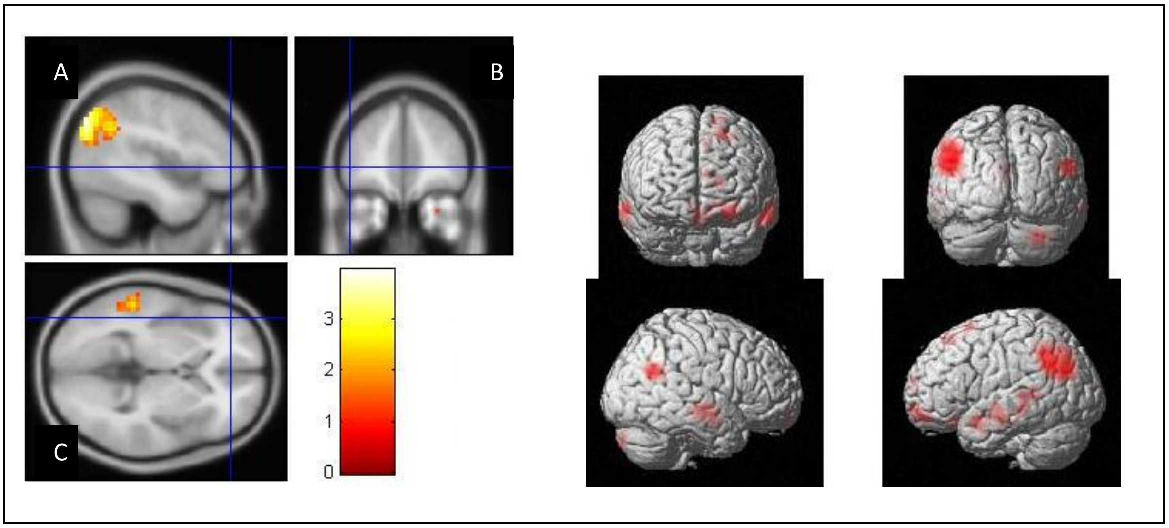


Activation maps from random effects analysis for phonological processing of word pairs greater than perceptual control of letter match condition in Subject 2 at A) pre-intervention and B) post-intervention. Renderings of the significant activations are presented on the frontal and posterior views and the lateral aspect of each hemisphere (the frontal view and the right hemisphere is on the left side of the graphic). Activation slice A shows a saggital view, slice B is a coronal view and slice C, the transverse view , with the crosshairs on IFG in both sets of maps. The calibration bar indicates *t* values for comparison ar each area presented on the slice views.

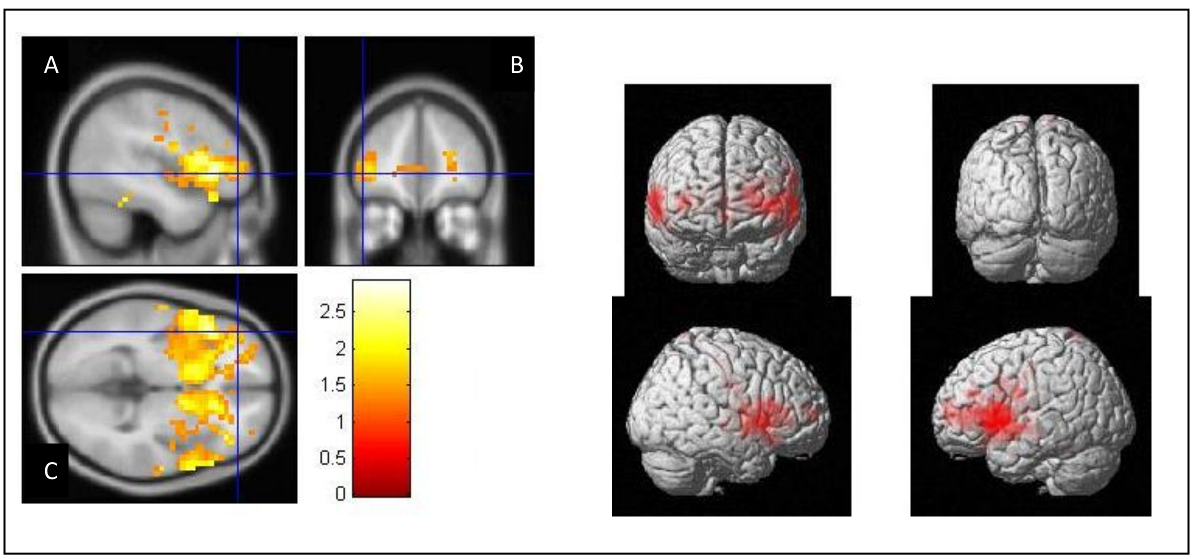
Figure 5

Selected Activation Maps of Subject 3

A. Pre-intervention activation in Subject 3



B. Post-intervention activation in Subject 3



Activation maps from random effects analysis for phonological processing of word pairs greater than perceptual control of letter match condition in Subject 3 at A) pre-intervention and B) post-intervention. Renderings of the significant activations are presented on the frontal and posterior views and the lateral aspect of each hemisphere (the frontal view and the right hemisphere is on the left side of the graphic). Activation slice A shows a saggital view, slice B is a coronal view and slice C, the transverse view , with the crosshairs on IFG in both maps. The calibration bar indicates *t* values for comparison ar each area presented on the slice views.

Using a clustering threshold of 5 voxels, a sample of the activation locations were found post-intervention in the condition of word pairs over letter match in a fluent subject. Table 4 contains a partial list of left hemisphere only activation sites, noting the location, relative size, and maximum recorded t-score.

Table 5

Locations of Significant Activation

Structure	*x*	*y*	*z*	Cluster Size	Max t score
ROI-IFG					
LH Inferior Frontal Gyrus	-48	24	12	523	1.52
LH Superior Temporal Gyrus	-60	-28	12	352	3.10
LH brodmann area 41	-56	-20	12	147	3.71
LH brodmann area 22	-64	-8	4	129	1.45
LH Insula	-36	-16	12	119	1.97
LH brodmann area 42	-60	-20	-12	114	3.94
LH brodmann area 13	-40	-16	12	73	1.93
LH Precentral Gyrus	-56	-8	12	67	1.66
ROI-STG					
LH Superior Temporal Gyrus	-40	-40	16	233	2.56
LH Angular Gyrus	-52	-64	36	86	2.46
LH Insula	-42	-16	16	68	2.21
LH Postcentral Gyrus	-52	-31	52	33	3.87
LH brodmann area 13	-44	-16	16	29	3.08
LH Inferior Parietal Lobule	-52	-36	28	26	2.74
LH brodmann area 40	-52	-24	16	11	3.16
LH brodmann area 39	-52	-68	28	10	2.42
LH Sub-Gyral	-48	-8	16	8	1.73
ROI-VWFA					
LH Sub-Gyral	-36	-4	-32	30	1.54
LH Middle Temporal Gyrus	-40	0	-32	19	1.42
LH brodmann area 20	-44	-8	-32	7	1.80
LH brodmann area 21	-40	-4	-32	5	2.05
LH brodmann area 35	-24	-16	-32	5	2.01
LH Fusiform (aal)	-28	-24	-32	5	3.06

These data show some expected activation areas with substantial groups of voxels involved and some surprising lack of activation within the ROIs. The largest activated cluster in the IFG ROI is the Inferior Frontal Gyrus (1.52), but activation in the STG (3.10), and brodmann areas 41 (3.17) and 42 (3.94) is much stronger. This could indicate that most of the processing in this region involved sound/symbol associations with support in the primary and auditory association cortex. The weak activation in the IFG, which supports the encoding of phonological features, could mean that less effort was required to accomplish the phonological analysis task by this subject.

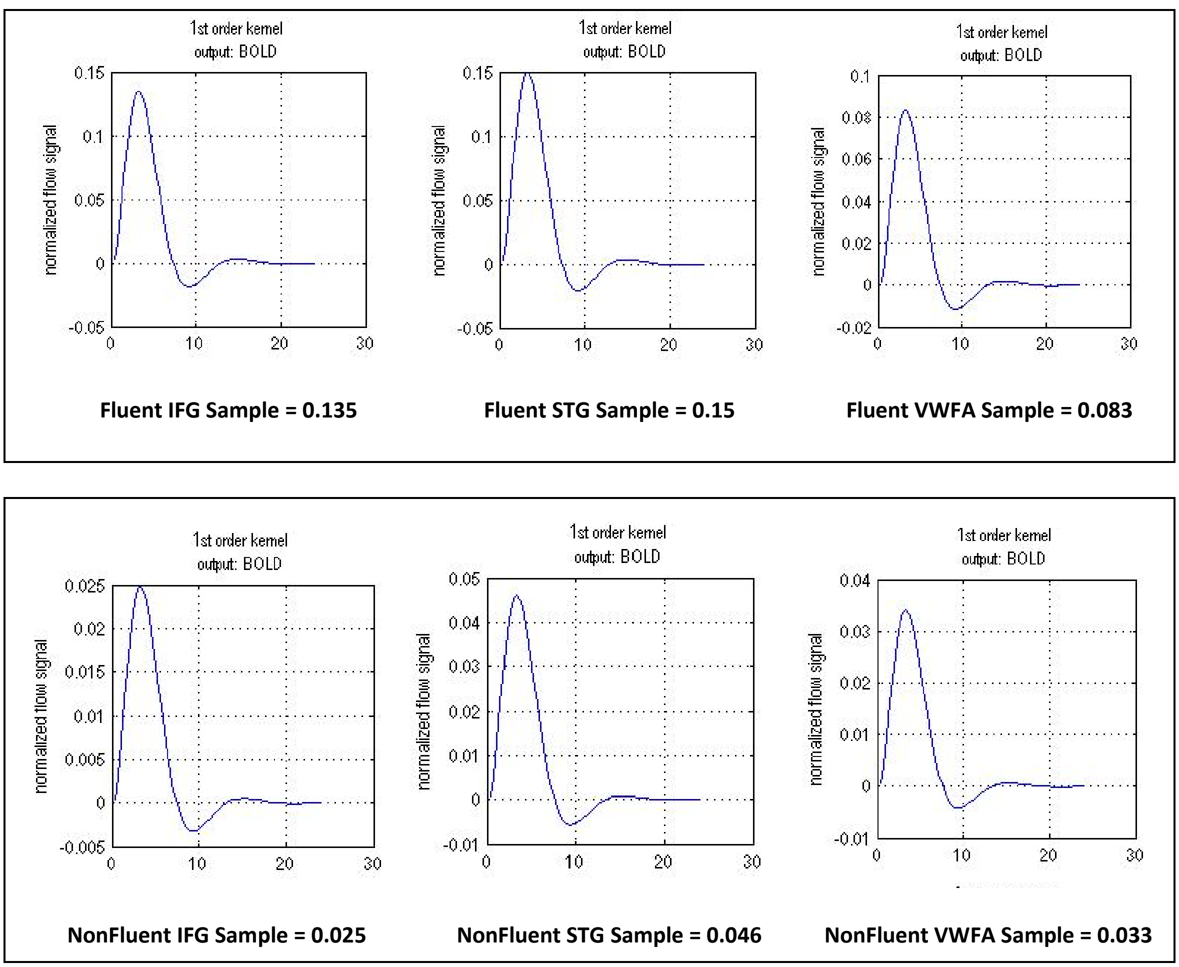
The largest activated cluster in the STG ROI is the STG (2.56), but again, other areas show stronger levels of activation. The Postcentral Gyrus activation (3.87) is unusual in that this area is the primary somatosensory cortex receiving all sensory input, especially touch and there was no variation in the motor demands of the task that would explain activation in this area. The activation found in brodmann areas 13 (3.08) and 40 (3.16) makes sense in that area 40 is part of Wernicke's Gyrus where sound/symbol associations are refined and area 13 is a bridge between lateral and medial layers. The Postcentral activation could be evidence of compensatory systems being used for phonological analysis in immature processing systems.

The largest activation in the VWFA ROI is found in the smallest clusters identified. The brodmann areas 21 (2.05) and 35 (2.01) appear to support automatic processing through their connection to Medial Temporal Gyus, thought to access word meaning, and the perirhinal cortex, important to memory. The left aspect of the Fusiform Gyrus shows the strongest activation (3.06) as would be expected if automatic retrieval of letter patterns was being used. So taken together, the activation locations identified in the subjects of this study, generally follow activation patterns found in the literature.

The hemodynamic response (HDR) is the change in MR signal on T_2* images following local neuronal activity. This response results from a decrease in the amount of deoxygenated hemoglobin present within a voxel. These graphs show a standard canonical model of HDRs that were processed from data taken from scans of fluent (A) and nonfluent subjects (B) focusing on the regions of interest: Inferior Frontal Gyrus, Superior Temporal Gyrus, and Visual Word Form Area. The scale of the x-axis in these graphs, the duration of the response, is in seconds. This is too gross to capture any differences in the latency of the response from region to region. However, the scales of the y-axes, the amplitude of the response, allow comparison of the magnitude of HDR activation in each of the ROIs, even though they vary somewhat in their rates of measurement.

Figure 6.

Hemodynamic Activation in ROIs



The levels of normalized flow signal from voxels in the IFG, STG, and VWFA ROIs of a sample fluent subject show different levels of activation. Analyses of the levels of activation indicate that the STG ROI activation is the strongest (0.15), the IFG activation is next robust (0.135), and the VWFA is the least strong (0.083). These levels of activation during the phonological analysis condition could indicate the student's use of phonological encoding and rule-based analysis more than their automatic word retrieval system.

As might be expected, the same activation assessments in a sample nonfluent subject are lower in amplitude as compared to the activation in the fluent sample. However, the order of magnitude is different for the nonfluent sample. Analyses of the levels of activation indicate that the STG ROI activation is again the strongest (0.046), but in this nonfluent sample, the VWFA activation is next robust (0.033), and the IFG is the least strong (0.025). These extremely low levels of measured activation reflect virtually no significant activation and make this a potentially important finding. Current literature on amplitude of signals in fMRI reveals that these measurements are often the focus of resting state vs. focused activation studies and are not commonly used in educational research. These results would seem, however, to provide further evidence of hypoactivation of key brain regions required for reading.

Discussion

This research was designed to test the hypothesis that subtyping students with the characteristics of dyslexia and administering VHSS intervention based on those subtypes (FlashWord-modified), would improve fluency performance across dyslexia sub-types more effectively than other currently used reading fluency programs. It was expected that VHSS training would increase fluency scores in students with the characteristics of dyslexia who participated in the intervention significantly more than those with dyslexia who did not participate. Further, it was hypothesized that regarding post-intervention activation, brain regions which are critical to the training of fast processing in reading would be identified and the effects in the brain that signify the development of fluency would be revealed.

To that end, students with reading disability contributed reading fluency scores and participated in fMRI imaging using a word pair (phonological analysis) and a letter match (perceptual control) task. The students assigned to the Intervention group participated in 24 hours of intervention prescribed by their reading errors and many achieved a very fast rate of automatic word/phrase reading in either the right or left visual hemi-field. The students in the Delayed Intervention acted as the control, since they did not use the intervention until after the second scan and a matched control group of non-impaired readers (to provide the same data points as Lorusso, et al., 2006) was not available.

In spite of a small N and unequal samples, differences were found in the pre- and post-intervention scores which varied by group. The average difference between pre-intervention and post-intervention fluency scores for the Intervention group was 11.9

wpm and the average difference for the Delayed Intervention group was 7.3 wpm. As the Delayed Intervention subjects demonstrated little or no change in their reading speed during the study, Intervention subjects showed change approaching statistical significance. Data that showed that the pre- and post- scores for both groups differed from each other significantly from the beginning of the study to the end could be possibly attributable to the effects of the intervention, but the Delayed Intervention students also made gains without it. One such student actually changed schools during the study and happened to also make a dramatic increase in reading fluency at a very low reading level. It would be difficult to assess the exact cause of such reading increases without understanding a myriad of potential factors affecting each subject.

It was determined that the Intervention group data set included data from subjects who achieved a fast level of word and phrase processing through their interaction with FlashWord and data from subjects, who despite the same length of treatment, did not reach levels of automaticity. Emerging automaticity is defined by processing in the 100-250 ms range and six of the nine students in this group reached word, and in some cases, phrase processing that reached 40-80 ms. Some students who demonstrated mixed processing deficits were assigned both the RH and the LH programs and reached automaticity in one program, but not the other. One student who was assigned the RH program on the basis of his reading errors was later found to have right hemisphere lesions and scarring; he completed the least number of lists and did not reach automaticity. So it seemed appropriate to separate the Intervention group into two subsets: those subjects who reached automaticity and those who did not, to examine the connection between gains in achieved fluency and increases in reading fluency. This data finally shows a significant relationship between the connected text reading of students and their achieved fluency speed with FlashWord.

There is considerable evidence that different students responded to the intervention differently. Those students who only displayed phonics-based errors in reading connected text and worked for the entire intervention time in the LH Program seemed to make the most substantial increases in both processing and reading speed. Only one student who demonstrated meaning-based errors and used the RH Program exclusively showed faster processing during intervention. The students who displayed both types of errors and split their time between programs made the least amount of progress; two reached fluency in the LH Program, but not in the RH Program. It is suggested that continued work with the intervention program could achieve the desired level of automaticity and that strengthening processing in the right hemisphere is inherently more difficult than strengthening the left hemisphere. Perhaps because older right hemisphere readers have established these inefficient connections over time and that must be abandoned (extinguished) in order to create more effective ones.

Functional magnetic resonance imaging was not a component of the Lorusso, et al. study. Therefore, the addition of fMRI technology, coupled with the small N's of the resulting subgroups, makes the results of this research very exploratory. Additionally, the fMRI data analysis was hampered by the poor quality of the images and lack of post-intervention data. During the scanning session, every subject is given a squeeze bulb that sounds an alarm in the control room for safety purposes. They are instructed to squeeze the bulb if they need to get out of the scanner for any reason. While only one subject ended the session before the task was complete in the pre-intervention scans, four subjects stopped the session early during the post-intervention for various reasons. This, in addition, to the removal of images from analysis because of movement artifacts, decreased the number of images that are suitable for analysis. However, general activation patterns identified in literature were observed: increased RH or bilateral activation in brain features involved in phonological processing and hypoactivation in LH features, and the VWFA (Shaywitz, et al, 2002 & 2004, Simos, et al., 2005, Pught, et al., 2001, Goswami, 2008).

Perhaps most indicative of the expected changes in neural processing from the effects of the intervention is the finding of consistently higher amplitude of activation in all explored regions in the fluent group as compared to the amplitude of activation seen in the nonfluent group. These changes in amplitude could be the direct result of the selective hemispheric stimulation provided by the intervention and therefore, represent the expected differences in processing most definitively. However, amplitude is not correlated with either latency to onset or latency to peak, so these data do not allow any judgment of temporal resolution.

There is substantial evidence that the FlashWord intervention was successful in increasing processing and reading speed in many of the subjects. Frederiksen, Warren, and Roseberry (1985) produced what is considered the seminal work demonstrating the beneficial effects of flashed presentations on phonological decoding and word identification. Snellings, Van der Leij, de Jong, and Blok (2009) report that many studies in the field focused on the sublexical level to generate transfer effects and not on the repeated-word level, which affects only word-specific knowledge. The overlearning of trained words, often the result of commonly-used, read-reread fluency strategies, does not seem to generalize to learning because it does not affect the processing of new words. Huemer, Landerl, Aro, and Lyytinen (2008) found that a focus on sublexical items increased reading fluency on the trained consonant clusters, but the generalization effects were small. The results of this study show that students do not achieve at the same rate using FlashWord; individual differences in processing strengths and weaknesses, as well as general language ability seemed to influence student proficiency within the given time constraint. However, the high rate of success for those in the Intervention group, both in achieving a level of automized processing and increasing reading speed of connected text, may provide some validation for the benefits of accurate subtyping. All but two subjects in the Intervention group achieved emerging fluency in either word or phrase processing components of their assigned program. Even though statistical analysis was not possible due to the extremely small samples, it is clear that the success of the intervention depends on accurate assessment of reading errors and assignment to the correct FlashWord program.

Lorusso, et al. (2006) found that Italian students with reading disabilities in three months treatment time gained .33 syllables per second (sps) more than their normal reading peers did in a year. This study used the Delayed Intervention group as a control sample and in the same time period, the Intervention group averaged a net gain of almost 5 wpm over the controls. Amir and Grinfeld (2011) provide a thorough review of the methodological complications of defining and comparing the metrics: words-per-minute and syllables-per-second. Generally, measurements in words-per-minute are found not to be equivalent to measurements in syllables-per-second, although some researchers have suggested that various conversion ratios could be used. However, there does not appear to be a consistent conversion ration because of differences in syllable length of words at more advanced reading levels. Therefore, this study will not attempt a more direct comparison to the Italian results.

There are other differences in comparing the Italian research and this replication in English, notably in the complexity of the orthography of the languages themselves. Wolf (2007) reports that the prevalence of dyslexia in Italy is half that in the U.S. and that prevalence estimates seem to be closely related to the shallowness of the orthography. She proposes that cross-language studies support the idea that the specific emphases of a writing system influences how the reading system breaks down. In less regular languages when phonological skills play a critical role in reading acquisition such as English and French, phoneme awareness and decoding accuracy are good predictors of dyslexia and are often very deficient. In languages with transparent orthographies and more logographic writing systems such as German, Spanish, Finnish, Dutch, Greek, and Italian, processing speed becomes the stronger predictor of reading performance and comprehension is deficit. This would suggest that children learning to read in the English language would have a more challenging task, with more potential deficit areas. For this study, these differences underscore the need of several students for more time to interact with the intervention in order to demonstrate increased proficiency and produce changes in neural processing systems.

In addition to critical differences in language orthography, some researchers have found interesting similarities between people with the characteristics of dyslexia regardless of their nationality. Paulesu, Demonet, Fazio, McCrory, Chanoine, et al. (2001) contrasted dyslexic and normal adult readers in deep (English and French) and shallow (Italian) orthographies to explore behavioral and neurophysiological similarities and differences. They found that Italian dyslexics, performed better on reading tasks than did English and French dyslexics. However, all dyslexics were equally impaired relative to their own language controls on reading and phonological tasks. Areas of significant activation in normal readers over dyslexic readers demonstrated in all nationalities included the left hemisphere STG, MTG, IFG, and middle occipital gyrus. Dyslexic readers revealed a greatly restricted pattern of activation which suggests that they have a less developed reading system. They conclude that there is a universal neurocognitive basis for dyslexia and that differences in reading performance among dyslexics of different countries are due to different orthographies. This explains the interesting finding that Chinese dyslexics also display a visual spatial memory deficit among their collection of processing factors that interfere with reading (Wolf, 2007).

As in any statistical analysis, derived conclusions can only be as good as the contributing data. This is especially true using fMRI images as a basis for analysis and underscores the challenges of collecting useful, functional data from children and teens. The movement parameters of images are automatically smoothed with a 3 mm blurring filter during preprocessing, but serious artifacts of movement involving as little as 5 mm in any direction can weaken signal strength and jeopardize precise feature location. However, there is also a possibility that the scattered activations present in the images that were collected in this study represent a diffuse pattern of processing thought to be evidence of compensatory functions. It was hypothesized that fluent processing would be accompanied by increased LH activation in the regions of interest, so all of the data points were located in the left hemisphere to capture this anticipated development. Since another typical processing profile in readers with disability is hypoactivation of these features in the left hemisphere, the lack of activation in non-fluent readers might be expected. Unfortunately, even narrowing the data set to include those students who had reached levels of automaticity did not produce significant differences in the levels of activation in the regions of interest.

There remains much to understand regarding the activation of the Visual Word Form Area in the left fusiform gyrus and its relationship to the development of fluent reading. According to Cohen, Dehaene, Naccache, Lehericy, Dehaene-Lambertz, et al. (2000), a standard model of word reading proposes that visual information is initially processed by occipitotemporal areas contra-lateral to the stimulated hemi-field. Then it is transferred to the visual word form system (VWFA), a left temporal region devoted to the processing of letter strings. Using fMRI, they identified a highly significant activation in the left fusiform gyrus (Talairach coordinates: $x = -42$, $y = -57$, $z = -6$) that was strictly unilateral and remarkably stable across subjects. Since their research also included comparisons of activation from the right and left visual hemi-fields, they concluded that the VWFA lies at the convergence of retinotopically organized visual pathways and contain visual neurons with receptive fields in both hemi-fields. They hypothesize that the VWFA may be homologous to inferotemporal areas in the monkey where cells with wide receptive fields, selectivity to high-level visual features, and size and position invariance have been found. If this is the case, it is possible that the human VWFA holds a distributed representation of the visual shapes of letters such that specific alphabetic strings are distinguished and is thought to supply instantaneous recognition of learned letters, letter patterns, and unique words.

Cohen, Lehericy, Chochon, Lemer, Rivaud, et al. (2002) hypothesized that an area located in the mid-portion of the left fusiform gyrus contributes crucially to the cerebral basis of automatic word recognition. This area activates whenever literate subjects read printed words and so they propose that this left fusiform region be labeled the Visual Word Form Area (VWFA). They found that the VWFA produced stronger activations to words, both real and readable pseudowords, than to strings of consonants. They conclude that the VFWA is initially plastic and becomes attuned to the orthographic regularities that constrain letter combinations during the acquisition of reading skills. This study included the VWFA as a region of interest because of its role in fluent processing of written language. However, the choice of scanner task items may have limited the actual activation related to this automatic retrieval by not including sight words (words that do not reflect phonological analysis that must be memorized). Activation in the VWFA was not significantly different from activation in the other regions of interest and was not even identifiable in many subjects' images. Theoretically, the stimulus of various letter patterns should also activate this area, so the cause of the hypoactivation of the VWFA in this study is possibly correctable with a modified scanner task.

There are results from different technologies that support the general patterns of activation documented in this study. Using magnetic source imaging (MSI), Simos, Breier, Fletcher, Foorman, and Bergman et al. (1999) identified aberrant activation maps consisting of reduced activity in temporoparietal areas in the left hemisphere: the posterior part of the STG, angular gyrus, and supramarginal gyri and increased activation in the corresponding right hemisphere regions. They also found a consistent procession of activation from occipital, to basal temporal regions including the posterior fusiform and lingual gyri (BTC) and finally to temporoparietal (TMP) areas with dyslexics displaying significantly longer onset latencies in both the TMP and BTC.

Their study tested two predictions of dual-process models of reading: that the brain structures involved in sublexical phonological analysis and those involved in whole-word phonological access during reading are different, and that the reading of meaningful items is mediated by different brain structures than the reading of meaningless letter strings. Reading of meaningful items required a high level of activation of the LH posterior Middle Temporal Gyrus (MTG) and mesial temporal lobe areas. Reading of meaningless letter strings was characterized by much reduced activation of these two areas. In addition, pronunciation speed of exception words requiring unique phonological processing with meaning correlated significantly with the onset of activity in the MTG, but not the Superior Temporal Gyrus (STG). The opposite was true for the processing of nonsense words that sound like real words and therefore have meaning, and the processing of nonsense words with no meaning, highlighting the differential functions of these areas. They went on to suggest STG activation during exception (sight words) word reading may actually indicate automatic engagement of this area not phonological processing as MTG activation appears to reflect lexical access that is secondary to phonological assembly. Even without including data from the VWFA, these researchers found differential activation in core reading subsystems depending on the requirements of the processing and infer automaticity in the STG, a condition described by current definitions of fluency at sub-lexical levels of processing.

Historically, many researchers have addressed the importance of automaticity in reading. As author, Maryanne Wolf, attempts to elucidate potential sources for dyslexia, she discusses the failure to achieve automaticity within or among the reading structures. In addition to documenting the considerable differences in the speed of processing visual information in subjects with the characteristics of dyslexia, research on how quickly children with dyslexia process auditory information indicates similarly longer intervals required to process brief separated tones. Breznitz (2006) even identified a consistent "gap in time" between the visual and auditory processes of poor readers. This appears to be the same anomaly Charles Perfetti (1985) described as "asynchronous word processing, the failure of processing events to have been completed in time for subsequent events to use their output". She relates this deficit to the success of the "naming speed" task as one of the single best predictors of dyslexia and suggests that in many cases of dyslexia, the brain never reaches the highest stages of reading development because it takes too long to connect the earliest parts of the process. In other words, a sufficient level of automatization was never attained at the early phonological and phonemic levels to support rapid processing of written language.

Another potential source of dyslexia seen by Wolf is an impediment in the circuit connections among the brain structures, stressing the importance of understanding the connectivity among the various regions instrumental to reading performance. She proposed at least three forms if disconnections which are consistently studied: between the frontal and posterior language regions based on underactivity in the connecting insula; and between the occipital-temporal region or the left angular gyrus region and frontal areas in the left hemisphere. She suggests that children with dyslexia use an altogether different reading circuitry. Instead of a progressive disentanglement of the right hemisphere's larger visual recognition system in reading words and an increasing engagement of left hemisphere's frontal, temporal, and occipital-temporal regions, they used more frontal regions, showed less activity in the left-hemisphere angular gyrus, and created potentially compensatory "auxillary" right-hemisphere regions which performed functions usually handled by more efficient left-hemisphere areas. The fMRI results from this study underscore Wolf's proposal. It may be that much of the diffuse frontal activation that was observed in many pre-intervention scans and some post-intervention scans of nonfluent subjects is evidence of these compensatory "auxillary" strategies. It may be that in older readers who have over time consolidated less efficient pathways for reading, more exposure is required for specific hemispheric stimulation (intervention) to supplant frontal and right hemisphere functions with effective left hemisphere processing.

There were several limitations to the effectiveness of this research. The sample was too small in size and did not allow for reliable comparison of the dyslexia sub-types as they related to each other and to the intervention program they used. The small sample and their youthful ages also increased the challenge of obtaining useable data. Movement artifacts decreased the number of functional images and the high rate of "squeeze bulbing" displayed during the post-intervention scanning, served to limit the quantity of post-intervention images that were available for analysis. Being limited to the analysis of selected ROIs from literature, may have reduced the significant findings based on the demands of the scanner task. More extensive analysis of areas involved in phonological processing only, or the addition of a third scanner task requiring the automatic recall of sightwords, could improve the statistical analysis outcomes.

Finally, it was extremely difficult working with administrators in some of the schools, even though compliance was expected to be easier to achieve in private facilities. Regular administration of the intervention was often directed by school leaders who regularly failed to follow through and/or communicate necessary adjustments to the intervention schedule. However, the parents of all of the participants were understanding and completely supportive of the requirements of the research, so individual intervention goals were met and post-intervention fluency scores were obtained.

The future for this kind of interdisciplinary research is extremely inviting, in part because of the strength of this type of computer technology as an intervention tool. Saine, Lerkkanen, Ahonen, Tolvanen, and Lyytinen (2010) conducted a longitudinal intervention study designed to build a model of predictive values of reading fluency using three different instructional techniques to identify the most effective type of intervention for children with different profiles of core pre-reading skills. Their results show that a computerized remedial reading intervention called GraphoGame was the most successful in remediating reading fluency in Finnish children (7 yrs. old) with deficits in letter knowledge, phonological awareness, and rapid automatized naming. Perhaps reflecting its extremely shallow orthography, (there is full symmetric consistency between graphemes and phonemes and the simplest syllabic structure in the Finnish language) and the fairly long duration of intervention (66 hours), increases in fluency were found in both of the other treatments (remedial reading instruction and mainstream instruction) as well, with the least amount of growth shown in the mainstream group. However, evaluation of data by pre-reading profiles shows that all of the tested profile-types responded most strongly in the computerized reading program.

The GraphoGame program is similar to FlashWord in the structure of the phonological analysis, proceeding from early reading competencies to higher-level concepts, and in the forced, fast processing at the word-level. It was developed to affect the cognitive operations that constitute word reading: the visual identification of orthographic units, their transformation into an internal sound and its articulation. This program's creators included the appearance of letters and words at an accelerating rate on the screen (although without hemisphere consideration) in an effort to improve automatized naming and visual recognition more effectively than flashcards. The direct comparison of traditional instructional techniques to outcomes produced through a computer-based intervention underscores the power of these types of programs and their impact on the automatization of lexical and sub-lexical reading processes.

Further research is clearly needed to understand the processes of fluent reading. Continued refinements to computerized intervention systems such as standardization of word list length, the addition of voice-recognition software and immediate feedback systems would make this kind of program much more "user-friendly". It would be interesting to include more pre- and post-intervention assessments of sublexical reading skills (i.e. rapid naming, orthographic pattern recognition) and lexical reading skills (i.e. comprehension) and flexible intervention durations to provide a better basis for understanding individual competencies that contribute to or result from automatic processing. Given that many of these skills appear to be part of developmental processes that are thought to be maturity or age-related, a much larger sample with a longitudinal component could help parcel out those effects that are specifically related to the intervention.

It remains to be seen whether the human brain reaches some level of development which decreases the plasticity of neural processes to respond to neurobiological training. Similar to this study's results, Tressoldi, Lorusso, Brenbati, and Donini (2007) found robust increases in teenaged Italian students reading speed after the intervention comparable to those achieved by their younger colleagues. Until that level of diminishing plasticity is determined, the potential for VHSS to impact positive change for non-fluent readers of every age is unknown, but extremely promising.

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APPENDIX A

FLASHWORD INTERVENTION PROGRAMS

General Directions for FlashWord

1. Creating a card-

From the Main Menu (Menu' Principale) click on Patient Cards (Scheda Paziente). This is required only if more than one student will be using this computer and program. (And perhaps not even then, since we are not using their system for verifying the results.) The small box will prompt you to name the file, using the child's last name will do. Then you can enter the child's information onto the card: first and last name, age, type of program used (LH, RH, or Mixed).

Useful Italian:
"Seleziona" = Select; "Copia" = Copy; "Aggiungi" = Add; "Incolla" = Paste; "Svuota" = Empty;

"Elimina" = Delete; "Stampa" = Print; "Esci" = Exit; "Apri File" = Open File.

2. Preparing for the rehabilitation session-

From the Main Menu click on Define Exercise (Definisci Esercizio) and the next screen contains all of the parameters that we can control for the presentation of the stimulus words.

The Fixation System:

In this square it is possible to directly define the speed that the cursor moves and the dimension (tolerance) of the target which underlies the fixation system of the tachistoscope.

The possible values are 1 to 10. An increase in the value corresponds to a faster speed of the cursor and more tolerance (the amount of variation from a standard allowed) of the target. The most difficult settings are when the speed is 10 and the tolerance equals 1.

Start with a **low speed (2 or 3)** and a **high tolerance (9 or 10).** Adjust these settings only if your student has good hand-eye coordination and wants to be challenged.

Timing the Presentation:

As needed, one can specify in the text box the value in milliseconds that the video image of the word will be shown. One can directly type the number value after having clicked with the mouse so that the cursor appears in the text, or one can click on the button at the side (UP and DOWN) to change the value by +/- 10 milliseconds.

The main purpose indicated is that the value also represents a class of relative duration that is of special worth in the timing of the presentation. The timing of the latter should be decreased as low as possible during the course of treatment as long as the student's accuracy does not fall below 70%.

Start with a **duration that is fairly high (1000 ms for words, 2000 ms for phrases).** Decrease the duration time within and between sessions as the student experiences success.

*****The Position of the Subject- Do this once and then keep the seating the same as much as possible.*****

For the correct execution of the lesson, the subject must be position before the screen following standard ways and shrewdness.

First as needed, one must know what the diagonal dimension is on the monitor which will be used. This value is generally known because it is supplied by the company that made it. It is usually expressed in inches (1 inch = 2.54 cm). If one does not know this value, then measure the diagonal of the monitor using a tape measure, that is, the diagonal of the rectangle that normally forms the image. One can click on inches (pollici) to set up the value of the diagonal by moving the button [UP] and [DOWN], or by writing the value directly in the text box.

The next procedures for possibly modifying the distance between the subject looking at the topic in the center of the screen, are discussed briefly in "Distance to the Screen". The predefined value of 60 cm indicates a normal distance of the subject from the monitor.

Remember to seat the subject in a chair with adjustable height so that his/her point of vision is at the center of the screen.

The Position of the Stimulus

By means of a mouse click in the proper square, the selection or deactivation of all three positions is allowed: Left (Sinistra), Center (Centrale), and Right (Destra). All combinations between these three positions are available. The default value is the center presentation.

It is necessary highlight and click to deactivate the center position, and highlight and click the square for the Left (Sinistra) or Right (Destra) positions.

The **LH program will always choose DESTRA** (the right side presentation).
The **RH program will always choose SINISTRA** (the left side presentation).

Directory of Lists of Words

To see the lists (files) that contain the stimuli, words and brief phrases with a maximum length of up to 20 characters, as needed press the button [LISTE] put at the right side of the window of exercise definitions. Through this command one can access the window, Directory of Lists (Elenco delle Liste) where it is possible to choose the lists of words to present.

In the selection window found at the top left of the screen, it is possible to specify the drive, the directory, the extension, and the name of the list you want to use.

<u>All of the lists you need for each program are already loaded onto that program.</u>

Examine Lists-

Through pressing Examine Lists (Esamina Lista) it is possible to give a glance at the contents of the lists that have been selected by highlighting and clicking on the name in the box at the top left of the screen.

<u>Be sure to consult the Master List of the program to find the coded name of each lesson</u>.

Note: The order of lessons on the Master List is also reflected in the organization of this binder. It is recommended to complete the lessons straight through the binder and repeat the sequence as many times as needed.

With the Add key (Aggiungi) it is possible to transfer the highlighted file to the box in the lower left which then contains the words which have been chosen for the exercise. After selecting one ot mre lists ot words, confirm the choice with [OK].

It is possible to select until there is a total of six lists. After they are confirmed they will come into view in the center box of the window Exercise Definitions.

To remove one or all of the lists in the center square, highlight and use the Remove command (Rimuovi).

Another aspect of the presentation of the lists of words is found in the choice (in the square "Lists of files.." contained in the window Exercise Definitions) between the representation in sequence or randomly of all of the words.

<u>**Always** choose no randomization by **clicking the box and deactivating "Applica random…Parole"**</u>**.**

Selecting the Presentation Font-

Press the key (Fonts) and it is possible to see a list of the *fonts* installed in your system. It is necessary then to click on the list of available fonts by highlighting the name of the selected font and click OK. Use the bar to scroll vertically to see all of the fonts. Suggested fonts are: Gungsuh, Agency FB, Aharoni, Andalus, Arial Black, Berlin Sans

FB, Broadway, Comic Sans MS, Cooper Black. After selecting the character dimensions and have seen them in the box at the bottom using the word with OK. Such a selection will be related in the space at the bottom right of the window Exercise Definitions.

The **LH Program** will **always** use the **default font.**
The **RH Program** should use a **different font** for **each session**.

Selecting the Color-

Click on the Color button (Colori) to access a simple graphic menu through which it is possible to choose alternatives to the option First Level or letter color (Primo Piano) or the Background color (Stondo) and click on the color palette to compose both of the combinations of colors on the screen. The result is immediately visible in the box beneath and is also transferred to the window of Exercise Definitions.

The **LH Program** will **always** use the default colors: **black letters on yellow background.**
The **RH Program** should **change the colors of the letters and the background** for **each session.**

Mode of Response-

In this box, one can opt for a written response where the subject actually types the word in a text box, or an oral response. The system does not allow automatic comparison of accuracy results with an oral response. This is why you and the binder are so important!

Repeat Word (Ripeti Parola) allows you to present again the preceding word, in the case that the subject got it wrong and you want them to see it again. We will always allow this so that "teachable moments" may be taken advantage of.

It is extremely important to record the speed, tolerance, and duration of the presentation to show student progress. Please enter these values at the top of each lesson page that is completed during your session.

3. Executing the session-

From the Main Menu click on Start the Exercise (Esegui Esercizio).
The student clicks on Proceed (Prosegui) to open the moving cursor and target. When the student clicks again as the cursor enters the target box, the word will appear. Use Repeat (Ripeti) in the upper left hand corner of the screen to look at a word again.

For each stimulus word, mark the student's response on the corresponding page in the binder. Use a checkmark for correct and an X for wrong. If the Repeat function was used please indicate with R. It is helpful to try and record what the student says for item analysis.

The PI will be responsible for calculating the percentage correct for each lesson. Please feel free to contact her if you have questions about a child's performance.

Use ALT T to modify the speed or tolerance of a session.
Use ALT Q to quit.

PLEASE DON'T FORGET TO RECORD THE NUMBER OF MINUTES THE STUDENT WORKED ON THE INTERVENTION ON THE TIME SUMMARY PAGE. THIS IS THE ONLY WAY WE WILL KNOW WHEN A STUDENT HAS COMPLETED THE REQUIRED AMOUNT OF TIME.

Master List – LH Program

Lesson #. Coded name = Word List

* Trai#331 = Training Program
1. shortv~1 = Short Vowels- 1
2. shortv~2 = Short Vowels- 2
3. shortv~3 = Short Vowels- 3
4. shortv~4 = Short Vowels- 4
5. sh6d2c~1 = Short Vowels- 5
6. phrases~1 = Phrases 1
7. phrases~2 = Phrases 2
8. vcepat~3 = Vce pattern- 1
9. vcepat~4 = Vce pattern- 2
10. vcepat~2 = Vce pattern- 3
11. vcepat~1 = Vce pattern- 4
12. cosona~1 = Consonant Blends- regular
13. phrases~3 = Phrases 3
14. ph83eb~1 = Phrases 4
15. regula~2 = Regular long e patterns
16. regula~1 = Regular long a patterns
17. regula~4 = Regular long o patterns
18. regula~3 = Regular long i patterns
19. suffix~1 = Suffixes
20. ph87eb~1 = Phrases 5
21. vrpatt~1 = VR patterns
22. diphth~1 = Diphthongs
23. conson~1 = Consonant Blends- irregular
24. phrase~4 = Phrases- 3sw
25. irregu~2 = Irregular long a patterns
26. irregu~3 = Irregular long e patterns
27. irregu~1 = Irregular consonants
28.phe04b~1 = Phrases- 4sw
29. fss-1 = Final Stable Syllables- 1
30. fss-2 = Final Stable Syllables- 2
31. fss-3 = Final Stable Syllables- 3
32. phe24b~1 = Phrases- 5sw
33. irregu~4 = Irregular vowel patterns
34. prefixes = Prefixes

Master List – RH Program

* rhtrai~1 = Training Program
1. rhshor~1 = Short Vowels- 1
2. rhshor~2 = Short Vowels- 2
3. rhshor~3 = Short Vowels- 3
4. rhshor~4 = Short Vowels- 4
5. rhfded~1 = Short Vowels- 5
6. rh-rel~2 = Related Words 1 (one letter change)
7. rh-phra~1 = Phrases 1
8. rh-hvi~1 = High Value Image words- 1
9. rhvcep~1 = Vce pattern- 1
10. rhvcep~2 = Vce pattern- 2
11. rhvcep~3 = Vce pattern- 3
12. rhvcep~4 = Vce pattern- 4
13. rh-con~2 = Consonant Blends- regular
14. rh-rel~3 = Related Words 2 (one letter change)
15. rh-hiv~1 = High Value Image words- 2
16. rh-phr~2 = Phrases 2
17. rhregu~2 = Regular long e patterns
18. rhregu~1 = Regular long a patterns
19. rhregu~4 = Regular long o patterns
20. rhregu~3 = Regular long i patterns
21. rh-suf~1 = Suffixes
22. rh-phr~4 = Phrases 3
23. rh-rel~1 = Related Words 3 (syllables)
24. rh-hvi~2 = High Value Image words- 3
25. rh-vrp~1 = VR patterns
26. rh-dip~1= Diphthongs
27. rh-con~1 = Consonant Blends- irregular
28. rh-phr~1 = Phrases 4
29. rh-hiv~2 = High Value Image words- 4
30. rh-fss~1 = Final Stable Syllables- 1
31. rh-fss~2 = Final Stable Syllables- 2
32. rh-fss~3 = Final Stable Syllables- 3
33. rh-irr~1 = Irregular vowel patterns
34. rh-rel~3 = Related Words 4 (words)
35. rh-phr~4 = Phrases 5
36. rh1783~1 = Related Words 5 (words)
37. rh-pre~1 = Prefixes

Sample Intervention Binder Page:

Speed / Duration
Tolerance

____/________ ____/________ ____/________

LH Training Program

Word	Date	Date	Date
and			
go			
shut			
ten			
black			
gift			
hot			
ruler			
need			
made			
line			
truck			
read			
white			
pole			
stamp (16)			

(% correct) __________% __________% __________%

LH Training Program (16)
and
go
shut
ten
black
gift
hot
ruler
need
made
line
truck
read
white
pole
stamp

LH Short Vowels-1 (50)
add
at
bag
brand
can
cast
clam
cramp
dad
drab
flag
gas
grab
had
hat
lamp
man
nag
pal
past
raft
rap
sand
slab
snap
stamp
tan
trap
vast
after
ax
bat
brass
cap
cat
clamp
dam
fact
flat
glass
grand
ham
jab
land
map
pad
plan
rag
sad
slap

LH Short Vowels-2 (50)
bed
bend
bled
clef
dent
egg
fell
fled
get
hem
jet
left
men
nest
peg
pet
red
sell
sled
sped
stress
tent
vent
web
went
wet
yelp
beg
bent
blend
crest
desk
fed
help
kept
leg
mend
net
pen
press
rent
send
slept
spell
swept
test
vest
wed
wept
yell

LH Short Vowels-3 (52)
bib
bin
dig
fib
fist
hid
his
jig
kiss
lint
milk
mitt
nip
pin
rid
rim
sift
sip
skill
still
swim

till
twist
wiff
wit
zip
bid
dill
fig
fix
hill
hit
kid
lid
lip
miss
pin
rift
rip
silk
sit
slit
strip
tin
vim
wig
yip
big
dim
fill
grin
him

LH Short Vowels-4(52)

bog
box
clod
cob
con
crop
dog
drop
fox
got
hot
loft
loss
mod
moss
on
plot
pop
rod
slob
smog
spot
toss
bond
clog
cod
cop
cross
doll
flop
frost
hog
job
log
lost
mom
nod
ox
pod
pot
rot
slop
snob
stop
boss
clop
cog
cost
dot
fog
fond
gloss

LH Short Vowels-5

bluff
bud
bump
bunt
clump
crust
cup
drum
dump
fun
glum
gruff
gun
hub
hum
hunt
jump
lug
mud
must
plum
pump
rug
rust
slug
stun
sunk
trust
tusk
up
blunt
buff
bun
bus
cub
cut
dug
dusk
fund
glut
grump
huff
hump
husk
just
lull
mug
null
plus
pup
rum
rut

LH Phrases 1 (25)

Hem the dress
Kept the red egg
Get the bell

Dress is a mess
Press his neck
A dump truck
Dull stuff
The truck and the bus
Dump the stuff
In a trunk
Got soft
Long hot dogs
Stop the doll
Pop off
Plod to the top
Pass the lamp
Ask the champ
Plant the land
Cat nap
Slap that
Six pigs
Lift the lid
Big stick
Kiss his chin
Kid will win

LH Phrases 2 (33)

Shake the snake
It is a shame
Trade the plane
Grade and name
Shape of the flake
Life of crime
Ride bikes
Fire in the pipe
Smile at the tribe
Pile the wire
For a dime
Broke his nose
Wore a robe at home
A coke and a cone
Spoke in the dome
Rode home
A cute mule
Use the ruler
Tube of prunes
Tune the flute
A Yule dude
Dish of shells
Put on a fresh shirt
Wish to shop
A thick bath cloth
This month
Think thin
When and why
White whale
Whack the wheel
A chunk of cheese
A cherry for lunch
Chose which chime

LH VCE Pattern-1 (49)

ale
babe
blame
brake
came
cave
date
drake
fade
flake
gate
glaze
grate
hate
lake
made
mate
nape
plane
rake
sake
save
skate
slave
stake
take
trade
ape
bale
blaze
brave
cane
crate
daze
drape
fake
flame
gave
grade
grave
haze
lame
make
maze
pave
plate
rate
sale
scrape
slate
snake
stale

LH VCE Pattern-2 (52)

bide
bride
crime
fire
gripe
kite
lime
mile
mite
pine
prize
ripe
sire
smile
strife
tile
tripe
vine
wide
wire
bile
brine
fife
five
hive
life
mime
nine
pipe
rife
rise

size
stile
time
vile
wife
wise
bite
file
glide
line
mine
pile
rite
slime
stripe
tire
vise
wine
bribe
fine
grime

LH VCE Pattern-3 (52)
bode
clone
coke
crone
dose
drove
hole
hose
lone
mope
poke
probe
rode
rove
smote
stone
stroke
tote
zone
bone
close
cone
dole
dote
froze
home
hose
joke
lope
node
pole
prone
rope
scope
sole
stove
vote
yoke
broke
clove
cope
dome
doze
globe
hope
lobe
mode
nose
pope
robe
rose
slope

LH VCE Pattern-4 (28)
brute
cube
dude
flute
mule
nude
prune
pure
rule
tube
Yule
crude
cute
duke
fume
jute
prude
puke
ruse
tune
dune
dupe
mute
fuse
rude
plume
use
June

LH Consonant Blends-Regular (56)
champ
cash
than
crash
that
dash
splash
trash
chest
bench
shed
shell
them
fresh
then
quench
when
dish
chin
inch
ship
pinch
thin
with
this
bunch
whip
crunch
flush
chop
broth
shock
cloth
moth
shop
slosh

shot
blush
chase
shade
shake
shame
shape
chime
shine
shrine
while
whine
white
chose
those
throne
whale
shave
choke
whole

LH Phrases 3 (52)
The people
Write it down
By the water
Who will make it?
You and I
What will they do?
He called me.
We had their dog.
What did they say?
When would you go?
No way
A number of people
One or two
How long are they?
More than the other
Come and get it.
How many words?
Part of the time
This is a good day.
Can you see?
Sit down.
Now and then
But not me
Go find her
Not now
Look for some people
I like him.
So there you are.
Out of the water
A long time
We were here
Have you seen it?
Could you go?
One more time
We like to write.
All day long
Into the water
It's about time
The other people
Up in the air
She said to go
Which way?
Each of us
He has it.
What are these?
If we were older
There was an old man
It's no use
It may fall down.
With his mom
At your house
From my room

LH Phrases 4 (50)
It's been a long time.
Will you be good?
Give them to me.
Then we will go.
Now is the time
An angry cat
May I go first?
Write your name.
This is my cat.
That dog is big.
Get on the bus.
Two of us
Did you see it?
The first word
See the water
As big as the first
But not for me
When will we go?
How did they get it?
From here to there
Number two
More people
Look up
Go down
All or some
Did you like it?
A long way to go
When did they go?
Of your people
For some
Over the river
My new place
Another great sound
Take a little
Give it back.
Only a little
It's only me.
I know why.
Three years ago
Live and play
A good man
After the game
Most of the animals
Our best things
Just the same
My last name
That's very good
Think before you act
Mother says to now.
Where are you?

LH Reg. Long e Patterns (52)
bead
bee
beast
bleed
bleat
cheek
clean
creep
cream
eel
each
feet
eat
free
gleam

glee
heap
heed
lead
keen
leap
leek
mean
peek
peach
preen
plea
reel
preach
seep
ream
sheen
seal
sleet
speak
speed
steam
steel
teak
teem
veal
tree
wheel
scream
queen
squeak
street
please
speech
streak

LH Reg. Long a Patterns (50)

aid
bay
day
chain
gay
drain
lay
faith
play
gait
spray
laid
tray
paid
clay
plain
fray
raise
gray
snail
hay
strait
jay
train
may
waif
nay
wait
pay
ail
ray
bait
say
claim
dray
fail
stay
faint
stray
grain
way
jail
main
pail
raid
sail
stain
trait
wail
waist

LH Reg. Long o Patterns (42)

bloat
cloak
coat
foal
goad
hoax
loam
moan
oat
roach
roast
soak
toast
boat
coach
croak
float
goal
load
loan
oak
road
soap
throat
toad
show
glow
pillow
own
row
grow
flow
blow
throw
slow
crow
mow
sow
tow
rainbow
yellow
snow

LH Reg. Long I Patterns (26)

buy
by
blight
cry
bright
dry
fight
fly

flight
fry
fright
my
light
pry
might
shy
night
sky
right
sly
sight
spy
slight
try
tight
why

LH Suffixes (60)

sifting
skipper
clamped
clicking
rocker
frosted
clanging
steeper
filled
hanging
gripper
handed
panting
baker
greeted
banker
flossing
seemed
driller
hissing
missed
faster
kicking
hooded
hunter
licking
acted
dimmer
sacking
yelled
burner
kissing
banged
sweeter
docking
puffed
tossing
smoker
weekly
asking
pecked
diner
freely
hinting
licked
ruler
lonely
lifting
timely
cured
golfing
sweetly
tapper
honking
liked
blankly
sinking
later
lovely
stocking

LH Phrases 5 (50)

I need help.
I work too much.
Any old time
Through the line
Right now
Mother means it.
Same time tomorrow
Tell the truth
A little boy
The following day
We came home.
We want to go.
Show us around.
Form two lines.
A small house also
Another old picture
Write one sentence.
Set it up.
Put it there.
Where does it end?
I don't feel well.
My home is large.
It turned out well.
Read the sentence.
This must be it.
Hand it over.
Such a big house
Men asked for help.
A different land
They went here.
Get to the point.
Because we should.
Even the animals
Try your best.
Move over.
We found it here.
Study and learn
Kind of nice
Spell your name.
The good American
Change your clothes
Play it again.
Back off.
Give it away.
Answer the phone.
Turn the page.
The air is warm.
Read my letters.
It's still here.
Where in the world.

LH VR Patterns (67)

berth
birch
blur
fern
chirp
burn
herb
dirt
burst
jerk

first
curb
nerve
girl
curse
perch
shirt
curve
perk
smirk
hurry
person
swirl
lurk
reverse
third
purple
serpent
twirl
return
serve
spurt
turkey
are
bar
card
carpet
carve
charm
dart
farm
hard
harp
lark
market
parch
party
scarf
smart
starch
tart
yard
born
cord
for
form
horn
lord
north
pork
score
snore
sport
storm
thorn
worn

LH Diphthongs (58)

boil
boy
coin
decoy
hoist
enjoy
joint
joy
loin
loyal
noise
ploy
oil
royal
point
toy
spoil
annoy
voice
destroy
void
about
bow
amount
brown
blouse
clown
cloud
cow
couch
crowd
doubt
drown
flour
frown
found
growl
grouch
now
house
owl
loud
plow
mouse
power
ouch
prowl
pout
shower
round
town
shout
wow
south
yowl
trout
without

LH Consonant Blends-Irregular (81)

back
pick
clock
neck
black
sick
truck
smock
crack
deck
sack
rock
stick
pack
crock
fleck
luck
stack
lock
tacks
track
peck
brick
dock
pluck
chick

stock
struck
shock
wick
catch
clutch
match
fetch
stitch
quack
quake
quell
quench
quote
queen
quest
quick
queer
quite
quill
quip
wrist
wreck
wrap
wrench
wreck
wrest
wring
write
wrong
wrote
wrung
wreath
king
rang
sang
bang
rung
sprung
sting
wing
song
knife
knit
know
knee
knelt
known
knob
knock
knot
phone
phase
photo
phrase

LH Phrases 3sw (25)
the little boy
a good boy
is about me
then you give
was to come
old and new
what we know
that old man
in and out
not up here
good for you
down at work
with his cat
it was new
work on it
can come here
they will go
are so long
three of them
before this one
your little boy
as long as
but not me
be here again
have been good

LH Irreg. Long a Patterns (21)
eight
survey
reindeer
grey
weight
they
eighteen
reign
weigh
whey
freight
veil
eighty
obey
sleigh
vein
neighbor
convey
beige
neigh
their

LH Irreg. Long e Patterns (51)
brief
either
baby
niece
neither
candy
ceiling
priest
peppy
receive
chief
valley
dusty
seize
thief
jockey
slimy
weird
brief
donkey
foggy
protein
field
turkey
muddy
deceive
yield
trolley
wavy
leisure
shriek
galley
glassy
sheik
achieve

hockey
drafty
perceive
relieve
key
lady
pierce
kidney
shield
monkey
thorny
diesel
alley
believe
chimney
study

LH Irreg. Consonants (80)
cab
cell
cake
center
calendar
cinch
came
cite
can
civil
candy
cycle
cane
cent
card
circle
carpet
city
carton
cereal
cave
cider
coast
cinder
cobweb
citrus
coffee
central
colt
cinnamon
comment
ice
contest
force
cork
face
country
twice
cover
space
cube
price
cut
except
gab
gem
gain
gentle
gale
germ
gallop
giant
game
ginger
garden
gym
gas
gypsy
gate
general
globe
generous
goat
gesture
golf
giraffe
gossip
geography
grade
margin
grass
urgent
groan
agent
guess
magic
gulf
legend
gun
forge

LH Phrases 4sw (25)
he is it
I can go
they are here
one by one
good and wet
came with me
about a dog
had a hat
if you come
some good candy
up and down
her green hat
say and do
when they come
so I went
my little house
very good girl
all around
would you like
any good book
have you been
we are out
here and there
from my mother
a nice day

LH Final Stable Syllables – (74)
amble
brindle
baffle
ankle
bobble
bundle
bramble
buckle
candle
bubble
cuddle
chuckle
crumble
dwindle
crackle
dabble

fiddle
dribble
freckle
fondle
fumble
griddle
knuckle
gobble
handle
pickle
grumble
huddle
prickle
hobble
kindle
shackle
humble
middle
sickle
jumble
muscle
mumble
muffle
sparkle
paddle
nibble
sprinkle
puddle
nimble
suckle
riddle
pebble
tackle
saddle
shuffle
tickle
quibble
spindle
trickle
scuffle
ramble
twinkle
raffle
straddle
wrinkle
rubble
twiddle
ruffle
rumble
waddle
scribble
sniffle
stubble
stumble
thimble
waffle
tremble
tumble

LH Final Stable Syllables-2 (66)

angle
ample
bristle
dazzle
bungle
apple
castle
drizzle
dangle
cripple
hustle
fizzle
giggle
crumple
jostle
frazzle
haggle
dapple
nestle
muzzle
jingle
dimple
thistle
nozzle
juggle
nipple
wrestle
puzzle
jungle
pimple
battle
sizzle
mingle
ripple
bottle
shingle
rumple
brittle
sample
single
cattle
simple
snuggle
kettle
supple
spangle
little
temple
squiggle
mantle
topple
strangle
rattle
trample
struggle
scuttle
tangle
tingle
settle
wiggle
wriggle
shuttle
whittle

LH Final Stable Syllables-3 (53)

mention
expansion
station
mission
fiction
permission
function
transmission
caption
confession
notion
progression
attention
aggression
foundation
discussion
action

confession
fraction
profession
subtraction
thunderous
location
furious
addition
adventurous
edition
joyous
satisfaction
nervous
tradition
famous
rotation
humorous
vacation
poisonous
superstition
mountainous
erosion
cohesion
vision
explosion
adhesion
confusion
decision
precision
conclusion
revision
division
occasion
transfusion
evasion
incision

LH Phrases 5sw (25)
to go home
see the dog
then they went
look at us
yes and no
play with him
by the house
he was going
come to me
get the cat
in or out
one, two, three
to the man
a little dog
he has it
sit by them
how do you
like the book
in our car
what do you
make a book
which one is
this much is
about his frog
do you know

LH Irreg. Vowel Patterns (57)
blew
bloom
chew
boost
drew
coop
flew
food
grew
groom
new
loop
skew
moose
spew
proof
threw
roost
view
shoot
blue
spoon
due
stoop
fuel
tooth
glue
zoo
hue
school
true
August
claw
author
dawn
because
draw
fault
hawk
gaunt
lawn
haul
pawn
launch
scrawl
laundry
squaw
taunt
straw
pause
yawn
vault

LH Prefixes (49)
misled
subway
mistake
subtotal
mistook
subnormal
misspell
subhuman
misinform
subvocal
misfit
subscribe
misname
submarine
misprint
subgroup
mistrust
subheading
unbend
sublet
disband
subserve
untwist
dislike

untangle
dislocate
unexpected
discard
unzip
dismiss
unfit
disallow
unwrap
discolor
unbutton
disagree
undo
disarm
unwanted
disburse
uncork
disconnect
unhook
discount
untangle
disgrace

Right Hemisphere Program Lists

RH Training Program (16)
anf
ro
shat
tun
blick
goft
het
tuler
jeed
rade
lune
bruck
reat
whote
jale
stimp

RH Short Vowels-1 (50)
nad
dat
cag
trand
gan
dast
lam
pramp
kad
brab
glag
ras
tran
san
hap
samp
mab
dag
nal
rast
haft
pap
vand
glab
snaf
blamp
kan
trat
zast
aftel
ab
bap
crass
vap
jat
slamp
fam
gact
blat
flass
trand
lam
mab
pand
fap
rad
blan
mag
vad
glap

RH Short Vowels-2 (50)
sed
hend
gled
slef
nent
en
mell
gled
het
rem
vet
seft
fen
hest
teg
det
ned
vell
slen
speb
strem
temp
nent
meb
ent
seg
relp
feg
kent
blen
grest
tesk
jed
lelp
bept
weg
dend
nep
ren
bress
hent
wend
glept
spem
sweb
dest
vesp
yed
mept
kell

RH Short Vowels-3 (52)
dib
lin
tig
hib
nist
jid
ris
kig
biss
sint
pilk
ditt
mip
rin
nid
mim
hift
fip

skig
stid
swib
tid
twif
wim
wik
vip
wid
lill
sig
tix
vill
jit
nid
frid
lim
mip
pid
pift
rix
rilk
dit
slin
strit
tiv
vig
wip
yit
bis
dib
fis
frin
wim

RH Short Vowels -4 (52)
rog
hox
flod
pob
gon
brop
kog
trop
wox
fot
glot
toft
foss
bod
goss
ol
plov
gop
lod
slok
smod
spof
poss
rond
glog
hod
sop
pross
holl
flom
frot
hom
jod
lon
rost
lom
kod
mox
dod
mot
grot
slon
snog
stom
foss
blop
nog
tost
zot
mog
lond
sloss

RH Short Vowels-5 (52)
sluff
nud
gump
tunt
blump
frust
tup
brum
fump
jun
flum
cruff
mun
gub
num
vunt
tump
kug
tud
sust
flum
sump
zug
pust
blug
stup
tunk
drust
busk
um
flunt
nuff
dun
hus
wub
vut
fug
nusk
tund
blut
prump
luff
cump
susk
nust
tull
gug
rull
glus
jup
lum
dut

RH Related Words-1 (31)

can
pan
pat
pit
bit
bat
bad
sad
sod
sop
sep
hep
hen
hun
hum
tum
tim
tin
tid
bid
bod
hod
hot
hat
has
ras
rap
cap
cup
cut
mut

RH Phrases 1 (25)

Hem the table
Kept the red egg
Get the happy
Dress is a mess
Press his heck
A jump truck
Dull stuff
The truck baby
Dump the skull
In a trump
Got fun
Long hot dogs
Stop the doll
Pop over
Plod to the up
Pass the glad
Ask the stamp
Plant the sand
Cat full
Slap the day
Six pigs
Lid the spot
Big stock
Kiss his ship
Kid will twin

RH High Value Image Words- 1 (51)

little
said
look
all
black
good
pretty
there
want
they
again
could
know
often
walk
were
because
buy
many
pull
their
wash
done
eight
laugh
shall
from
was
come
word
people
two
would
follow
great
sentence
through
work
answer
different
large
above
children
earth
enough
example
important
school
once
though
father

RH VCE Pattern- 1 (52)

fale
cabe
glame
trake
mame
lave
sate
frake
hade
slake
vate
kaze
prate
nate
hake
rade
sate
pape
slane
dake
gake
bave
skame
slabe
stafe
tage
trafe
ane
hale

flaze
trave
nane
prate
taze
frape
nake
slame
mave
frade
prave
saze
bame
dake
jaze
vave
glate
jate
lale
scrake
slape
snabe
stafe

RH VCE Pattern- 2(52)
pide
dride
trime
vire
bripe
dite
kime
sile
zite
jine
drize
hipe
pire
smipe
stribe
hile
tripe
tine
mide
bire
jile
prine
kife
rive
sive
zife
pime
kine
nipe
dife
tise
bize
stite
fime
zile
pife
hise
tite
lile
glipe
kine
zine
kile
pite
slibe
strime
jire
dise
bine
fribe
zine
grife

RH VCE Pattern-3 (52)
pode
blone
moke
trone
jose
brove
gole
sose
vone
tope
foke
drobe
sode
gove
smode
stope
strote
bote
fone
jone
glose
rone
fole
cote
broze
kome
tose
roke
bope
tode
nole
trone
wope
scoke
sote
stobe
lote
doke
groke
flove
zope
fome
poze
pobe
fope
dobe
kode
wose
ope
hobe
bose
sloke

RH VCE Pattern- 4 (28)
prute
hube
bude
glute
sule
gude
brune
ture
fule
dube
jule

frude
rute
muke
pume
fute
frude
kuke
zuse
bune
vune
lupe
nute
huse
jude
blume
luse
sune

RH Consonant Blends-Reg. (56)
thamp
cach
whan
crath
shat
dach
splath
trach
thest
bensh
ched
thell
whem
frech
chen
quensh
shen
dith
whin
insh
thip
pinsh
whin
wich
shis
bunth
thip
crunsh
fluch
whop
broch
whock
closh
moch
thop
sloch
whot
bluch
whase
chade
thake
chame
whape
thime
chine
whrine
shile
chine
thite
shose
thuse
shrone
thale
chave
whoke
thole

RH Related Words-2 (50)
block
black
slack
stack
stall
small
smell
smelt
melt
malt
halt
holt
hold
told
folder
smolder
shoulder
bolder
boaster
poster
paster
chaser
laser
grazer
gravy
wavy
crazy
cradle
straddle
strangle
bangle
mingle
single
tingle
trickle
thick
chick
chock
clock
clack
click
brick
trick
sting
cha-ching
drink
drank
thank
yank

RH High Value Image Words-2 (51)
popcorn
baby
kitten
stop
airplane
butterfly
crayon
breakfast
elephant
balloon
hurry
love
monkey
picture

squirrel
woman
tomorrow
Wednesday
address
bicycle
caterpillar
banana
alligator
circus
feather
garden
doughnut
good-bye
great
hamburger
kitchen
helicopter
medicine
library
hundred
important
neighbor
island
ocean
rainbow
orange
police
possible
sugar
scissors
television
valentine
whisper
yesterday
yolk
vegetables

RH Phrases-2 (33)
Shake the sake
It is a lame
Trade the planet
Grade that name
Shape of the flake
Life of rime
Ride pikes
Fire in the site
Smile at the tribe
Pile the wire
For a mime
Broke his rose
Wore a robe at home
A coke and a cone
Spoke in the foam
Rode hope
A cute mule
Use the look
Tube of prunes
sing the flute
A Yule dude
Dish of shells
Put on a fresh short
Wish to shape
A thick path
This after
Think smile
Wet and why
White shade
Whack the queen
A chunk of tease
A cherry for hunch
Choose a running

RH Reg. Long e Patterns (51)
nead
ree
peast
fleed
gleat
cheen
clead
creet
creag
eem
eash
feep
eak
gree
bleam
plee
meap
keed
ead
meen
weap
neek
sean
heek
feach
breen
slea
deel
creach
feep
veam
sheed
seab
sleef
speam
speet
steab
steef
teag
teej
veat
bree
wheek
scread
queep
squeav
streeg
flease
speesh
streaf

RH Reg. Long a Patterns (38)
ait
vay
chaik
tay
frain
cay
naith
glay
dait
quay
taid
dray
jaid
blain
zay
baise

cray
snaim
straif
traip
wais
wain
aib
baid
claip
faid
smay
haint
frain
jait
maig
paiv
raib
sais
staip
traib
waig
daist

RH Reg. Long o Patterns (40)
sloat
bloak
noat
poal
moad
roax
toam
goan
oal
voach
foast
hoak
poast
joat
foach
groak
fload
goap
loat
loap
oad
roal
soaf
throas
toaf
thow
fow
tillow
owp
zow
trow
kow
shrow
spow
prow
quow
fow
gow
dainrow
nellow

RH Reg. Long I Patterns (22)
py
glight
ry
tright
dy
pight
ly
clight
fy
gright
duy
kight
quight
hy
hight
sy
zight
dight
nuy
smight
thight
chy

RH Suffixes (61)
tifting
stipper
blamped
plicking
gocker
trosted
slanging
steener
villed
manging
bripper
panded
ganting
daker
freeted
manker
slossing
heemed
briller
tissing
lissed
kaster
vicking
pooded
dunter
bicking
racted
mimmer
cacking
delled
furner
nissing
zanged
sweemer
bocking
fuffed
jossing
smober
feekly
rasking
secked
viner
treely
vinting
micked
tuler
wonely
hifting
limely
hured
dolfing
sweebly

happer
ponking
niked
glankly
hinking
pater
bovely
stucking

RH Phrases 3 (52)
The purple
Write it town
Buy the water
Who will make in?
You and who
What pill they do?
He taller me.
We had their fog.
What did they may?
When would you toe?
No bay
A street of people
One or to
How song are they?
More that the other
Come and wet it.
How many toads?
Part of the lime
This is a good ray.
Can you hee?
Fit down.
Now and when
But not late
Go rind her
Not cow
Look some people.
I spike him.
So their you are.
Pout of the water
A long dime
We were more
Have you been it?
Could you so?
One door time
We like to nite.
All day tong
Into the outside
It's about finish
The brother people
Up in the hair
She said to mow
Which pay?
Each of feet
He has at.
What are theme?
If we were holder
There was a sold man
It's no tube
It may hall down.
With his step
At your mine
From my broom

RH Related Words-3 (33)
everyday
daylight
lightning
brighten
frighten
anywhere
wherever
everybody
bodysuit
suitable
ability
itty bitty
pitty pat
pat-a-cake
cakewalk
walkway
wayside
sideboard
boardwalk
walky-talky
talk show
showoff
offbeat
beat-up
updraft
drafty
crafty
handicrafts
handsome
somewhere
whereas
ashtray
treasure
surething
thing-a-ma-bob
bobcat

RH High Value Image Words-3 (51)
adventure
apostrophe
barbeque
alphabet
beauty
ambulance
anxious
bulb
celebrate
chalk
business
canyon
chimpanzee
chocolate
caution
cartoon
cause
buffalo
dandelion
danger
cocoon
delicious
creature
comma
diamond
dictionary
curious
dinosaur
cruel
discover
firecracker
excite
experiment
elastic
earth
familiar
fossil
elementary
engine
garage
ghost

giraffe
heart
icicle
graham
hippopotamus
index
honest
guitar
handkerchief
hospital

RH VR Patterns (66)
ferth
pirch
plur
hern
shirp
murn
jerb
zirt
nurst
serk
kirst
lurb
derve
birl
turse
ferch
thirt
lurve
nerk
stirk
purry
merson
skirl
durk
deverse
chird
gurple
ferpent
twirp
heturn
werve
shurt
nurkey
lar
plor
mard
parset
farve
tharm
bart
jarm
tard
narp
sark
tarket
harch
darty
starf
snart
smarch
vart
dard
norn
pord
jor
scorm
vorn
kord
torth
gork
smore
thore
slort
snorm
chorn
jorn

RH Diphthongs (57)
doil
koy
goin
becoy
poist
entoy
soint
foy
boin
moyal
roise
proy
oik
foyal
moint
voy
stoil
anjoy
poice
testroy
hoid
akout
jow
apount
trown
flouse
glown
bloud
yow
souch
drowd
roubt
prown
plour
trown
gound
browl
prouch
gow
nouse
owt
voud
smow
fouse
vower
oush
frowl
nout
chower
dound
bown
chout
gow
houth
rowl
crout
withouf

RH Consonant Blends-Irreg. (81)
bick
nock
cleck

beck
bluck
seck
druck
slock
brack
meck
fack
prock
smick
gack
trock
pleck
vuck
swack
kock
gracks
twack
leck
drick
gock
bluck
chuck
snock
streck
shick
wock
zatch
flutch
ratch
jetch
stotch
quock
quike
quoll
quinch
quate
queep
quem
quid
queel
quase
quall
quep
wrust
wrick
wrep
wronch
wrack
wrost
wrang
wrete
wrunt
wrute
wrunk
wreash
ging
tang
kang
lang
fung
spung
sming
wong
vong
knike
knip
knowl
kneet
knult
knon
knof
knuck
knat
phobe
phate
pholo
phrame

RH Phrases 4 (50)

It's been a long dime.
Will you be food?
Live them to me.
Then we sell go.
Wow is the time
An angry hat
May I go thirst?
Write your same.
This is my bump.
That dog is wig.
Get on the musk.
Two of keep
Did you veer it?
The first heard
See the sound
As dig as the first
But not for he
When will we not?
How did they met it?
From here to where
Number on
Store people
Look see
Go brown
All or many
Did you bike it?
A long pay to go
When lid they go?
Of sour people
For none
Over the giver
My new place
Another great found
Wake a little
Give it black.
Only a skittle
It's pony me.
I no why.
Tree years ago
Live and pay
A good fan
After the tame
Post of the animals
Our nest things
Just the blame
My list name
That's berry good
Wink before you act
Mother says to cow.
Where are foot?

RH High Value Image Words-4 (51)

kangaroo
lightning
liquid
marshmallow
kindergarten
lizard
lollipop
message
larva
lullaby
machine

microwave
million
mosquito
pajamas
mushroom
mystery
officer
onion
perimeter
piano
recess
rectangle
pumpkin
relax
poem
regular
remember
restaurant
quarter
rhyme
potato
president
sentence
skeleton
ruin
shadow
skyscraper
schedule
sheriff
sneeze
secret
soldier
special
terrible
telephone
square
thousand
stomach
umbrella
vacation

RH Final Stable Syllables-1 (74)

anble
brandle
paffle
abkle
bibble
bandle
dramble
huckle
randle
gubble
juddle
shuckle
prumble
dwandle
cruckle
labble
tiddle
gribble
breckle
sondle
kumble
driddle
knickle
gabble
mandle
dickle
trumble
nuddle
frickle
jobble
rindle
chackle
pumble
liddle
vickle
gumble
ruscle
numble
luffle
spirkle
daddle
mibble
sprankle
tuddle
limble
duckle
hiddle
mebble
lackle
baddle
whuffle
bickle
quobble
stindle
frickle
scaffle
tamble
twonkle
daffle
striddle
wrankle
gubble
twaddle
tuffle
pumble
gaddle
scrubble
snoffle
stabble
stemble
thomble
haffle
tramble
zumble

RH Final Stable Syllables-2 (63)

ingle
umple
brastle
pazzle
hungle
epple
mastle
trizzle
sangle
dripple
vustle
lizzle
higgle
frumple
lostle
prazzle
maggle
vapple
restle
fuzzle
ringle
mimple
shistle
tozzle

nuggle
fipple
wrostle
duzzle
fungle
kimple
zattle
hizzle
kingle
bipple
lottle
chingle
numple
trittle
lample
ringle
pattle
nimple
snoggle
bettle
pupple
spingle
fittle
vemple
squaggle
rantle
lopple
stringle
gattle
trimple
stroggle
scattle
vangle
hingle
lettle
riggle
wruggle
chuttle
thittle

RH Final Stable Syllables-3 (54)

tention
expinsion
stution
massion
fection
parmission
finction
trunsmission
cuption
confassion
nition
prograssion
attontion
uggression
foundition
discossion
ection
confussion
froction
profussion
subtriction
thanderous
lecation
murious
addation
udventurous
edation
poyous
sutisfaction
bervous
dradition
namous
potation
dumorous
nacation
loisonous
fuperstition
tountainous
erasion
cohusion
tision
explasion
abhesion
conbusion
recision
drecision
conclasion
sevision
bivision
occusion
dransfusion
etasion
ancision

RH Irreg. Vowel Patterns (52)

clew
floom
shew
moost
prew
joop
glew
rood
trew
proom
rew
voop
snew
koose
slew
droof
chrew
woost
biew
choot
plue
stoon
yue
spoop
suel
mooth
klue
joo
nue
schoog
brue
Aufust
blaw
authod
nawn
betause
graw
rault
nawk
maunt
jawn
kaul
sawn
vaunch
strawl
haundry

quaw
kaunt
staw
wause
tawn
jault

RH Related Words-4 (36)
bobcat
catwalk
walkway
wayward
warden
dentist
tintype
typecast
castoff
offhand
handout
outside
sideways
wayfaring
fairground
groundball
ballpark
parking lot
log cabin
cabin fever
fever blister
blistering
ring-a-ding
dingdong
donkey
keyhole
holster
stirrup
uptown
township
shipwreck
wrecking bar
barbell

RH Phrases 5 (50)
I seed help.
I work new much.
Any told time
Through the pine
Sight now
Mother meats it.
Same lime tomorrow
Well the truth
A middle boy
The following say
We came foam.
We want to what.
Throw us around.
Form two nines.
A small mouth also
Another sold picture
White one sentence.
Pet it up.
Put it chair.
Where does hit end?
I don't peel well.
My home is land.
It turned out bell.
Lead the sentence.
This crust be it.
Sand it over.
Much a big house
Men asked for yelp.
A different grand
They went hear.
Get to the oink.
Because we shoulder.
Seven the animals
Why your best.
Love over.
We sound it here.
Study and earth
Kind of twice
Smell your name.
The group American
Change your close
Play pit again.
Back of.
Give fit away.
Answer the foam.
Turn the cage.
The bare is warm.
Read my betters.
It's chill here.
Where in the word.

RH Related Words-5 (34)
fishtank
tanktop
top-heavy
heavy-handed
handshake
shakedown
downtown
townsman
manhunt
hundred
dredlocks
lockout
outrun
running board
boardwalk
walkthrough
throughout
outrage
railroad
roadhouse
housecoat
coattail
tailgate
gatekeeper
keepsake
safeguard
guardroom
roommate
matron of honor
honor roll
rollover
overpay
payday
daylight savings time

RH Prefixes (46)
misbed
subtay
misnake
subpotal
misrook
subdormal
misstell
subfuman
misunform
subjocal
mismit
subscrike
misrame

subharine
mistrint
subproup
misbrust
subdeading
unpend
submet
disland
subterve
untwost
disrike
ungangle
disnocate
unexpicted
dislard
untip
disliss
unbit
disallot
unwrop
dispolor
unhutton
disabree
unpo
disarl
unkanted
dislurse
unhork
dismonnect
undook
disbount
unfangle
disdrace

APPENDIX B

FLASHWORD INTERVENTION INDIVIDUAL RESULTS

Key to abbreviations used-

D = date of the session
S = speed of word presentation
NR = not recorded
DNA = lessons were not attempted because of instructional level of the student
NC = not completed

Student Code ________MA___________ Total Minutes ____720_____________

RH Program	D	S	%	D	S	%	D	S	%
Short Vowels- 1 (50)	3/23	900	88	4/12	400	98			
Short Vowels- 2 (50)	3/23	900	82	4/14	500	96			
Short Vowels- 3 (52)	3/23	900	94	4/14	500	NC			
Short Vowels- 4 (52)	3/23	900	88	4/18	500	92			
Short Vowels- 5 (52)	3/23	900	94	4/18	500	85			
Related Words 1(31)	4/18	500	97						
Phrases 1 (25)	3/23	1000	72	4/18	800	75			
H V I words- 1 (51)	3/23	1000	96	418	500	92			
Vce pattern- 1 (52)	3/24	1000	90	4/19	600	96			
Vce pattern- 2 (52)	3/24	1000	98	5/2	250	90			
Vce pattern- 3 (52)	3/24	1000	98	5/2	250	88			
Vce pattern- 4 (28)	3/24	1000	89	5/2	250	89			
Con. Blends- reg (56)	3/24	1000	96	5/2	250	75			
Related Words 2(50)	3/25	1000	88	5/2	250	86			
H V I words- 2 (51)	3/25	1000	100	5/2	250	98			
Phrases 2 (33)	3/25	2000	94	5/2	800	<70			
Reg long e patt. (51)	3/29	800	98						
Reg long a patt. (38)	3/29	600	100						
Reg long o patt. (40)	3/29	600	93	5/4	500	85			
Reg long i patt. (22)	3/29	600	86	5/4	500	100			
Suffixes (61)	3/29	900	<70	3/30	1500	78	5/14	500	75
Phrases 3 (52)	3/30	2000	94	5/4	700	92			
Related Words 3(33)	3/30	600	94	5/5	500	91			
H V I words- 3 (51)	3/31	600	<70	5/5	500	86			
VR patterns (66)	4/4	1000	83	5/8	500	89			
Diphthongs (57)	4/4	1000	75	5/5	500	86			
Con. Blends- irr (81)	4/4	1000	84	5/6	500	93			
Phrases 4 (50)	4/8	NR	80	5/6	800	82			
H V I words- 4 (51)	4/8	1000	92	5/6	500	96			
Final Stable Syl 1(74)	4/8	1000	72	5/6	500	70			
Final Stable Syl 2(63)	4/8	1000	78	5/9	500	83			
Final Stable Syl 3(54)	4/11	1000	<70	5/9	500	DC			
Irreg vowel patt.(52)	4/11	1000	87	5/9	500	85			
Related Words 4(36)	4/11	1000	83	5/9	500	92			
Phrases 5 (50)	4/11	1000	<70						
Related Words 5(34)	4/11	1000	88	5/9	800	94			
Prefixes (46)	4/11	1000	<70						

Student Code______MA__________ Total Minutes _____720___________

LHLesson(#items)	D	S	%	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	5/10	500	98	5/18	150	92	5/31	100	92	5/31	80	95
Short V- 2 (50)	5/10	500	96	5/18	150	94	5/31	100	98	5/31	80	98
Short V- 3 (52)	5/10	300	98	5/18	150	86	5/31	100	98	5/31	80	96
Short V- 4 (52)	5/10	300	100	5/25	120	96	5/31	100	94	5/31	80	98
Short V- 5 (52)	5/10	300	93	5/25	120	91	5/31	100	93	5/31	80	96
Phrases 1 (25)	5/10	300	96	5/25	250	84	5/31	200	84	5/31	175	92
Phrases 2 (33)	5/11	500	97	5/25	300	88	5/31	250	88	5/31	175	91
Vce patt- 1 (49)	5/11	250	96	5/25	120	84	5/31	100	98	5/31	80	95
Vce patt- 2 (52)	5/11	250	100	5/25	120	91	5/31	100	98	5/31	80	96
Vce patt- 3 (52)	5/11	250	100	5/25	120	96	5/31	100	87	5/31	80	92
Vce patt- 4 (28)	5/11	250	96	5/25	120	86	5/31	100	86	5/31	80	96
Con Bld- reg (56)	5/11	250	97	5/25	120	90	5/31	100	97			
Phrases 3 (52)	5/13	500	90	5/25	350	94	5/31	300	98			
Phrases 4 (50)	5/13	500	84	5/25	350	88	5/31	300	96			
Rg long e pat (52)	5/13	200	85	5/25	120	94	5/31	100	100			
Rg long a pat (50)	5/13	200	92	5/31	120	98	5/31	100	79			
Rg long o pat(42)	5/16	175	98	5/31	120	100	5/31	100	95			
Rg long I pat (26)	5/16	175	81	5/31	120	100	5/31	100	92			
Suffixes (60)	5/16	200	92	5/30	120	93	5/31	100	87			
Phrases 5 (50)	5/16	500	86	5/31	350	84	5/31	300	92			
VR patterns (67)	5/16	175	90	5/31	120	96	5/31	100	91			
Diphthongs (58)	5/17	500	100	5/31	120	98	5/31	100	90			
Con. Bld- irr (81)	5/17	500	91	5/31	120	98	5/31	100	83			
Phrases- 3sw (25)	5/17	500	88	5/31	250	92	5/31	200	84			
Irr. long a pat(21)	5/17	500	<70	5/31	120	81	5/31	100	81			
Irr. long e pat(51)	5/17	500	<70	5/31	120	82	5/31	100	76			
Irreg.conson.(80)	5/17	500	83	5/31	120	88	5/31	100	83			
Phrases- 4sw (25)	5/18	450	96	5/31	250	96	5/31	150	100			
F S S- 1 (74)	5/18	450	96	5/31	150	89	5/31	125	84			
F S S- 2 (66)	5/18	450	95	5/1	150	89	5/31	125	86			
F S S- 3 (53)	5/18	450	94	5/31	200	81	5/31	125	77			
Phrases- 5sw (25)	5/18	450	92	5/31	250	80	5/31	125	92			
Irr. vowel pat(57)	5/18	200	96	5/31	120	96	5/31	100	93			
Prefixes (49)	5/18	200	80	5/31	175	92	5/31	150	86			

Student Code______MC__________ Total Minutes ____1440____________

LHLesson (#items)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V-1 (50)	3/23	1000	98	3/30	600	100	4/7	250	96	4/19	200	96	5/4	100	96	5/17	90	98
Short V-2 (50)	3/23	1000	98	3/30	600	100	4/7	250	96	4/10	200	98	5/4	100	96	5/17	90	96
Short V-3 (52)	3/23	1000	96	3/30	500	98	4/7	250	94	4/19	200	96	5/4	100	98	5/18	80	98
Short V-4 (52)	3/23	900	98	4/4	500	98	4/7	250	98	4/19	200	100	5/4	100	98	5/18	80	94
Short V-5 (52)	3/23	900	94	4/4	400	96	4/12	200	94	4/19	200	96	5/4	100	100	5/18	80	92
Phrases 1 (25)	3/23	2000	100	4/4	100	100	4/12	350	100	4/19	250	100	5/4	250	96	5/18	80	84
Phrases 2 (33)	3/23	1500	94	3/24	1000	94	4/4	800	97	4/19	250	97	5/4	250	100	5/18	80	96
Vce patt-1 (49)	3/24	1000	92	4/4	400	98	4/13	200	100	4/20	200	100	5/4	100	100	5/18	80	92
Vce patt-2 (52)	3/24	1000	82	4/4	350	88	4/13	200	94	4/20	200	96	5/9	100	86	5/18	80	90
Vce patt-3 (52)	3/24	1000	75	4/4	350	96	4/13	200	98	4/20	200	100	5/9	100	90	5/20	80	90
Vce patt-4 (28)	3/24	1000	79	4/5	350	100	4/13	150	86	4/20	200	93	5/9	100	92	5/20	80	92
Con Bld-rg (56)	3/24	1000	94	4/5	350	98	4/13	200	94	4/20	200	100	5/10	100	92	5/20	80	96
Phrases 3 (52)	3/24	2000	98	4/5	700	98	4/13	700	100	4/20	250	100	5/10	250	100	5/20	150	92
Phrases 4 (50)	3/25	2000	100	4/5	700	100	4/13	600	98	4/20	250	96	5/10	250	100	5/20	150	98
Reg. long e (52)	3/25	1000	98	4/5	350	100	4/13	200	96	4/21	200	100	5/10	100	100	5/20	80	100
Reg.long a (50)	3/25	1000	100	4/5	300	100	4/14	250	94	4/21	200	94	5/10	100	96	5/20	80	100
Reg. long o (42)	3/25	1000	100	4/5	300	93	4/14	250	93	4/21	200	98	5/10	100	98	5/20	80	96
Reg. long i (26)	3/25	1000	100	4/6	300	100	4/19	250	100	4/26	200	100	5/10	100	100			
Suffixes (60)	3/28	1000	95	4/6	300	98	4/14	250	97	4/26	200	95	5/11	150	96			
Phrases 5 (50)	3/28	2000	100	4/6	600	98	4/14	250	100	4/26	250	98	5/11	250	100			
VR	3/2	900	96	4/6	30	97	4/	25	99	4/	20	99	5/	10	96			

patterns(67)	8				0		18	0		26	0		11	0				
Diphthongs(58)	3/28	900	96	4/6	300	98	4/18	200	100	4/26	200	100	5/11	100	98			
Con. Bld-irr(81)	3/28	900	93	4/6	250	94	4/18	200	96	4/26	200	95	5/2	100	95	5/11	100	98
Phrase-3sw(25)	3/28	1900	100	4/11	500	100	4/26	250	95	5/2	200	96	5/11	150	100			
Irr. long a (21)	3/29	900	95	4/11	250	90	4/18	200	95	5/2	100	96	5/13	90	100			
Irr. long e (51)	3/29	800	98	4/11	250	96	4/18	200	96	5/2	100	96	5/13	90	98			
Irreg. cons. (80)	3/29	700	91	4/11	250	93	4/18	200	96	5/2	100	96	5/13	90	96			
Phrase-4sw(25)	3/29	1700	100	3/29	1200	100	4/11	500	100	5/2	200	96	5/13	150	100			
F S S- 1 (74)	3/29	700	92	3/31	ND	78	4/11	250	93	5/3	100	92	5/13	90	91	5/16	100	82
2F S S- 2 (66)	3/29	700	84	3/31	ND	83	4/12	400	87	5/3	100	95	5/16	100	83			
F S S- 3 (53)	3/30	700	81	3/31	ND	94	4/12	1000	98	5/3	100	96	5/12	90	98			
Phrase-5sw(25)	3/30	1000	100	4/12	400	96	4/18	250	100	5/3	150	96	5/16	100	100	5/17	90	96
Irr. Vowel (57)	3/30	700	93	4/12	250	98	4/18	200	98	5/3	100	98	5/16	90	96			
Prefixes (49)	3/30	700	100	4/12	250	98	4/19	200	94	5/3	100	94	5/17	90	94			

Student Code______MD__________ Total Minutes _______720_________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	3/24	1000	100	4/12	700	100			
Short V- 2 (50)	3/24	1000	94	4/12	700	94			
Short V- 3 (52)	3/24	1000	88	4/12	700	4/12			
Short V- 4 (52)	3/24	1000	100	4/12	700	92			
Short V- 5 (52)	3/24	1000	96	4/12	700	88			
Phrases 1 (25)	3/25	1000	100	4/14	700	75			
Phrases 2 (33)	3/25	1000	94	4/14	700	<70			
Vce patt- 1 (49)	3/25	1000	94	4/13	700	94			
Vce patt- 2 (52)	3/25	1000	92	4/14	700	85			
Vce patt- 3 (52)	3/28	1000	<70	4/15	700	79			
Vce patt- 4 (28)	3/29	1000	96	4/15	700	75			
Con Bld- reg. (56)	3/29	1000	91	4/15	700	77			
Phrases 3 (52)	3/29	1000	75	4/19	700	85			
Phrases 4 (50)	3/29	1000	94	4/18	700	86			
Reg long e pat (52)	3/30	800	<70	4/18	700	86			
Reg long a pat (50)	3/30	800	72	4/18	700	75			
Reg long o pat (42)	3/30	800	74	4/18	700	81			
Reg long I pat (26)	3/31	800	96	5/2	500	92			
Suffixes (60)	3/31	800	75	5/2	500	85			
Phrases 5 (50)	3/31	1000	86	5/2	800	92			
VR patterns (67)	4/5	1000	91	5/2	500	92			
Diphthongs (58)	4/5	1000	90	5/2	500	93			
Con. Blends-irr(81)	4/8	1000	70	5/2	500	79			
Phrases- 3sw (25)	4/8	100	96	5/3	500	84			
Irr. long a patt (21)	4/8	1000	<70	5/3	500	<70			
Irr. long e patt (51)	4/11	800	71	5/3	500	73			
Irreg. conson. (80)	4/11	800	76	5/3	500	73			
Phrases- 4sw (25)	4/4	1000	98	4/11	800	98			
F S S- 1 (74)	4/4	1000	<70	4/6	1000	<70			
F S S- 2 (66)	4/4	1000	<70	4/6	1000	<70			
F S S- 3 (53)	4/6	1000	<70	5/3	500	<70			
Phrases- 5sw (25)	4/11	800	98	5/3	500	92			
Irr. vowel patt (57)	4/11	800	91	5/3	500	84			
Prefixes (49)	4/11	800	89	5/5	500	71			

Student Code _______MD____________ Total Minutes ______720___________

RH Program (#items)	D	S	%	D	S	%	D	S	%
Short Vowels- 1 (50)	5/6	800	70	5/20	425	77	5/26	400	87
Short Vowels- 2 (50)	5/6	800	70	5/20	425	75	5/26	400	85
Short Vowels- 3 (52)	5/6	800	<70	5/20	425	72	6/2	400	78
Short Vowels- 4 (52)	5/9	800	93	5/23	250	<70	6/2	400	89
Short Vowels- 5 (52)	5/9	800	85	5/23	250	<70	6/2	400	76
Related Words 1(31)	5/9	800	100	5/23	400	100	6/2	350	97
Phrases 1 (25)	5/9	1000	80	5/23	800	80			
H V I words- 1 (51)	5/9	500	96	5/23	400	96			
Vce pattern- 1 (52)	5/9	500	85	5/23	400	76			
Vce pattern- 2 (52)	5/10	500	<70	5/23	400	<70			
Vce pattern- 3 (52)	5/10	500	<70	5/23	400	76			
Vce pattern- 4 (28)	5/10	500	<70	5/23	400	<70			
Con. Blends- reg (56)	5/13	500	<70	5/23	400	<70			
Related Words 2(50)	5/13	500	81	5/23	400	73			
H V I words- 2 (51)	5/11	500	96	5/23	350	89			
Phrases 2 (33)	5/13	1000	<70	5/23	700	<70			
Reg long e patt. (51)	5/16	500	<70	5/24	250	70			
Reg long a patt. (38)	5/16	500	76	5/24	250	76			
Reg long o patt. (40)	5/16	500	75	5/24	250	75			
Reg long i patt. (22)	5/16	500	73	5/24	300	77			
Suffixes (61)	5/16	800	<70	5/24	300	<70			
Phrases 3 (52)	5/16	1000	<70	5/24	600	<70			
Related Words 3(33)	5/17	500	73	5/24	400	82	5/26	400	76
H V I words- 3 (51)	5/17	500	82	5/24	400	86			
VR patterns (66)	5/11	500	79	5/24	400	83			
Diphthongs (57)	5/11	500	79	5/24	400	88			
Con. Blends- irr (81)	5/11	500	<70	5/25	400	75			
Phrases 4 (50)	5/17	500	<70	5/25	400	78			
H V I words- 4 (51)	5/18	450	92	5/25	400	96			
Final Stable Syl 1(74)	5/18	450	<70	5/26	400	<70			
Final Stable Syl 2(63)	5/18	450	<70	5/26	400	<70			
Final Stable Syl 3(54)	5/18	450	<70						
Irreg vowel patt.(52)	5/18	425	71	5/26	300	<70			
Related Words 4(36)	5/18	425	89	5/26	400	83			
Phrases 5 (50)	5/18	475	<70	5/26	450	<70			
Related Words 5(34)	5/18	425	79	5/26	400	85			
Prefixes (46)	5/20	425	<70						

Student Code _______ME___________ Total Minutes _____1440___________

RH Program (#items)	D	S	%	D	S	%	D	S	%	D	S	%
Short Vowels- 1 (50)	3/23	1000	88	5/13	800	82						
Short Vowels- 2 (50)	3/23	1000	86	5/13	800	88						
Short Vowels- 3 (52)	3/23	1000	85	3/24	NR	85	5/13	800	83	5/16	500	80
Short Vowels- 4 (52)	3/24	NR	87	5/16	500	Inc	5/17	500	88			
Short Vowels- 5 (52)	3/24	1000	88	5/18	500	86						
Related Words 1(31)	3/24	NR	94	5/18	500	97						
Phrases 1 (25)	3/25	2000	96	NR	NR	88	5/18	1000	80			
H V I words- 1 (51)	3/25	1000	94	5/23	400	86						
Vce pattern- 1 (52)	3/25	1000	100	5/23	400	83						
Vce pattern- 2 (52)	3/28	1000	96	5/24	400	88						
Vce pattern- 3 (52)	3/28	900	88	5/24	400	98						
Vce pattern- 4 (28)	3/28	900	79	5/24	400	96						
Con. Blends- reg (56)	3/29	800	89	5/24	400	91						
Related Words 2(50)	3/29	700	84	5/24	400	96						
H V I words- 2 (51)	3/30	700	84	5/24	400	94						
Phrases 2 (33)	3/30	1900	<70	5/23	1500	82						
Reg long e patt. (51)	4/4	700	88	5/24	400	90						
Reg long a patt. (38)	4/4	700	84	5/24	400	92						
Reg long o patt. (40)	4/5	800	90	5/24	400	88						
Reg long i patt. (22)	4/5	700	95	5/24	400	95						
Suffixes (61)	4/6	1000	<70	5/24	600	87						
Phrases 3 (52)	NR	900	<70	5/24	1000	84						
Related Words 3(33)	4/11	1500	82	5/24	1000	97						
H V I words- 3 (51)	4/12	1500	<70									
VR patterns (66)	4/13	1500	88									
Diphthongs (57)	4/14	1500	95									
Con. Blends- irr (81)	4/14	1500	79									
Phrases 4 (50)	4/18	2000	78									
H V I words- 4 (51)	4/20	1500	<70									
Final Stable Syl 1(74)	4/26	1500	Inc	5/2	1500	87						
Final Stable Syl 2(63)	5/3	1000	80									
Final Stable Syl 3(54)												
Irreg vowel patt.(52)	5/5	1000	<70									
Related Words 4(36)	5/6	800	86									
Phrases 5 (50)	5/6	1000	<70									
Related Words 5(34)	5/10	800	88									
Prefixes (46)	5/11	800	<70									

Student Code______MF__________ Total Minutes _______1440_________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V-1 (50)	3/23	1000	76	3/30	700	100	4/11	200	100	4/18	150	100	5/2	100	100	5/9	100	100
Short V-2 (50)	3/23	1000	72	3/30	200	100	4/11	150	98	4/18	150	100	5/2	100	100	5/9	100	100
Short V-3 (52)	3/23	1000	88	3/30	150	98	4/11	150	100	4/18	150	100	5/2	100	98	5/9	100	98
Short V-4 (52)	3/23	1000	71	3/30	150	98	4/11	150	100	4/18	150	100	5/2	100	100	5/10	100	100
Short V-5 (52)	3/23	900	75	3/30	150	100	4/11	150	100	4/18	150	98	5/2	100	100	5/10	100	100
Phrases 1 (25)	3/23	2000	96	3/31	1000	88	4/11	400	100	4/18	250	96	5/2	150	100	5/10	150	100
Phrases 2 (33)	3/23	2000	100	3/31	1000	100	4/11	400	100	4/19	250	96	5/2	150	96	5/10	150	100
Vce patt-1 (49)	3/23	800	100	3/31	NR	100	4/11	150	94	4/19	150	100	5/2	100	98	5/10	100	98
Vce patt-2 (52)	3/24	NR	83	3/31	NR	98	4/12	150	96	4/19	150	98	5/5	100	100	5/10	100	96
Vce patt-3 (52)	3/24	NR	79	3/31	NR	100	4/12	150	100	4/19	150	98	5/3	100	100	5/10	100	100
Vce patt-4 (28)	3/25	1000	100	3/31	NR	100	4/12	150	95	4/19	150	100	5/3	100	100	5/10	100	100
Con Bld-reg. (56)	3/25	1000	100	3/31	NR	98	4/12	150	100	4/19	150	100	5/3	100	100	5/10	100	100
Phrases 3 (52)	3/25	2000	100	4/5	1600	100	4/12	300	98	4/19	250	100	5/3	200	98	5/11	200	98
Phrases 4 (50)	3/25	2000	100	4/5	1500	100	4/12	250	100	4/19	250	100	5/3	200	98	5/11	200	98
Reg long e pat(52)	3/25	1000	100	4/5	150	100	4/12	150	98	4/20	150	100	5/3	100	100	5/11	100	98
Reg long a pat(50)	3/28	900	100	4/5	150	100	4/12	150	98	4/20	150	98	5/3	100	100	5/11	100	100
Reg long o pat(42)	3/28	900	100	4/5	150	90	4/13	150	100	4/20	150	100	5/3	100	100	5/11	100	100
Reg long I pat (26)	3/28	800	100	4/5	150	95	4/13	150	95	4/20	150	100	5/4	100	100	5/11	100	100
Suffixes (60)	3/28	900	100	4/5	150	98	4/13	150	98	4/20	150	100	5/4	100	100	5/11	100	100
Phrases 5 (50)	3/28	1800	100	4/5	1500	98	4/13	250	96	4/20	250	100	5/4	200	96	5/11	200	100

VR patt (67)	3/28	700	100	4/6	150	99	4/13	150	100	4/20	150	100	5/4	100	100	5/13	90	99
Diphthongs (58)	3/28	700	100	4/6	150	98	4/13	150	100	4/21	150	98	5/4	80	100	5/13	90	100
Con.Blen-irr(81)	3/29	600	100	4/6	150	96	4/13	150	100	4/21	150	100	5/4	100	100	5/13	90	100
Phrases-3sw (25)	3/29	1600	100	4/6	1400	100	4/13	250	100	4/21	150	90	5/4	200	100	5/13	90	100
Irr. longa patt(21)	3/29	500	100	4/6	150	95	4/14	150	100	4/21	150	100	5/5	100	100	5/13	90	100
Irr. longe patt (51)	3/29	500	100	4/6	150	100	4/14	150	100	4/21	150	100	5/5	100	98	5/16	100	100
Irreg. cons(80)	3/29	400	99	4/6	150	99	4/14	150	100	4/21	150	100	5/5	100	100	5/16	100	100
Phrases-4sw (25)	3/29	1000	100	3/29	800	100	4/6	700	95	4/21	150	70	5/5	100	88	5/16	100	92
F S S- 1 (74)	3/29	400	100	4/6	400	99	4/14	300	100	4/26	150	100	5/6	100	93	5/16	100	100
F S S- 2 (66)	3/29	300	98	4/6	400	96	4/14	200	100	4/26	150	98	5/6	100	92	5/16	100	100
F S S- 3 (53)	3/30	400	100	4/6	400	100	4/14	300	98	4/26	150	100	5/6	100	93	5/16	100	100
Phrases-5sw (25)	3/30	600	100	4/7	400	95	4/14	300	95	4/26	200	95	5/6	100	76	5/17	100	92
Irr. Vow. patt (57)	3/30	300	100	4/7	NR	100	4/18	150	100	4/26	150	100	5/6	100	98	5/17	100	100
Prefixes (49)	3/30	300	100	4/7	400	100	4/18	150	98	4/26	150	98	5/6	100	98	5/17	100	100

Student Code_______MF2_________ Total Minutes ________________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	5/17	100	100	5/24	80	98	5/24	70	100
Short V- 2 (50)	5/17	100	100	5/24	80	100	5/24	70	100
Short V- 3 (52)	5/17	100	100	5/24	80	100	5/24	70	100
Short V- 4 (52)	5/17	100	100	5/24	80	96	5/24	70	100
Short V- 5 (52)	5/17	100	100	5/24	80	98	5/24	70	98
Phrases 1 (25)	5/17	100	100	5/24	80	100			
Phrases 2 (33)	5/24	100	88	5/24	80	100	5/24	70	100
Vce patt- 1 (49)	5/24	90	96	5/24	80	98	5/24	70	100
Vce patt- 2 (52)	5/24	90	88	5/24	70	100			
Vce patt- 3 (52)	5/24	90	92	5/24	70	100			
Vce patt- 4 (28)	5/24	90	96	5/24	70	100			
Con Bld- reg. (56)	5/24	90	98						
Phrases 3 (52)	5/24	150	96						
Phrases 4 (50)	5/24	150	92						
Reg long e pat (52)	5/24	90	100						
Reg long a pat (50)	5/24	90	100						
Reg long o pat (42)	5/24	90	90						
Reg long I pat (26)	5/24	90	96						
Suffixes (60)	5/24	90	98						
Phrases 5 (50)	5/24	150	90						
VR patterns (67)	5/24	80	97						
Diphthongs (58)	5/24	80	98						
Con. Blends-irr(81)	5/24	80	96						
Phrases- 3sw (25)	5/24	80	96						
Irr. long a patt (21)	5/24	80	100						
Irr. long e patt (51)	5/24	80	100						
Irreg. conson. (80)	5/24	80	98						
Phrases- 4sw (25)	5/24	80	92						
F S S- 1 (74)	5/24	80	95						
F S S- 2 (66)	5/24	80	100						
F S S- 3 (53)	5/24	80	98						
Phrases- 5sw (25)	5/24	80	96						
Irr. vowel patt (57)	5/24	80	100						
Prefixes (49)	5/24	80	100						

Student Code______MI__________ Total Minutes _____720___________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V-1 (50)	5/16	200	88	5/18	150	94	5/24	130	98	5/25	110	92	5/26	90	94			
Short V-2 (50)	5/16	200	90	5/18	150	94	5/24	130	100	5/25	110	100	5/26	90	98			
Short V-3 (52)	5/16	200	90	5/18	150	85	5/24	130	94	5/25	110	88	5/26	90	90			
Short V-4 (52)	5/16	200	98	5/18	150	88	5/24	130	92	5/25	110	100	5/26	90	98			
Short V-5 (52)	5/16	200	92	5/18	150	87	5/24	130	96	5/25	110	94	5/26	90	100			
Phrases 1 (25)	5/16	400	<70	5/18	175	<70	5/24	150	72	5/25	130	<60	5/26	150	75			
Phrases 2 (33)	5/16	400	<70	5/23	500	<70	5/24	150	<70	5/25	140	<70	5/26	150	<70			
Vce patt-1 (49)	5/16	200	96	5/23	150	84	5/24	130	96	5/25	110	94	5/26	90	100			
Vce patt-2 (52)	5/16	200	87	5/23	150	85	5/24	130	90	5/25	110	90	5/26	90	92			
Vce patt-3 (52)	5/16	200	92	5/23	150	81	5/24	130	88	5/25	110	92	5/26	90	94			
Vce patt-4 (28)	5/17	500	96	5/23	150	89	5/24	1430	89	5/25	110	93	5/26	90	100			
Con Bld-reg. (56)	5/17	500	91	5/23	150	86	5/24	130	95	5/25	110	89	5/26	90	96			
Phrases 3 (52)	5/17	1000	92	5/23	900	98	5/24	180	<70	5/25	700	92	5/26	600	98			
Phrases 4 (50)	5/17	1000	98	5/23	700	92	5/24	150	<70	5/25	600	92	5/26	550	94	6/2	500	92
Reg long e pat(52)	5/17	500	94	5/23	150	90	5/24	120	85	5/25	100	90	5/26	80	96	6/2	70	85
Reg long a pat(50)	5/17	300	98	5/23	150	84	5/24	120	96	5/25	100	94	5/26	80	98	6/2	70	92
Reg long o pat(42)	5/17	500	98	5/23	150	81	5/24	120	90	5/25	100	83	5/26	80	86	6/2	70	100
Reg long I pat (26)	5/17	400	92	5/23	150	85	5/24	120	100	5/25	100	92	5/26	80	96	6/2	70	92
Suffixes (60)	5/17	400	92	5/23	350	80	5/24	130	83	5/25	120	93	5/26	100	90	6/2	90	88

Phrases 5 (50)	5/17	300	<70	5/23	700	78	5/24	200	<70	5/25	650	88	5/26	600	88	6/2	550	94
VR patt (67)	5/17	500	96	5/23	150	85	5/24	120	94	5/25	100	99	5/26	80	94	6/2	70	91
Diphthongs (58)	5/17	200	95	5/23	150	90	5/24	120	90	5/25	100	97	5/26	80	97	6/2	70	97
Con. Ble-irr(81)	5/17	200	79	5/23	150	78	5/25	120	80	5/25	100	85	5/26	80	83	6/2	70	85
Phrases-3sw (25)	5/17	200	<70	5/23	800	88	5/25	180	<70	5/26	650	100	5/26	600	100	6/2	500	100
Irr. long a pat(21)	5/17	200	<70	5/18	150	<70	5/23	150	86	5/25	120	86	5/25	100	81	5/26	80	71
Irr. long e pat(51)	5/18	150	<70	5/23	150	82	5/25	120	76	5/25	100	82	5/26	80	80	6/2	70	90
Irreg. cons (80)	5/18	150	70	5/23	150	93	5/25	120	90	5/25	100	85	5/26	80	80	6/2	70	85
Phrases-4sw (25)	5/18	175	<70	5/23	150	84	5/25	140	<70	5/25	600	88	5/26	550	84	6/2	500	100
F S S- 1 (74)	5/18	150	<70	5/23	150	93	5/25	140	82	5/25	120	81	6/2	110	82			
F S S- 2 (66)	5/18	150	<70	5/23	150	90	5/25	140	83	5/26	120	81	6/2	110	85			
F S S- 3 (53)	5/18	150	<70	5/24	150	79	5/25	140	74	5/26	120	81	6/2	110	85			
Phrases-5sw (25)	5/18	175	<70	5/24	150	80	5/25	140	<70	5/26	120	84						
Irr. vow patt (57)	5/18	150	75	5/24	140	88	5/25	120	96	5/26	100	96						
Prefixes (49)	5/18	150	<70	5/24	140	<70	5/25	120	<70	5/26	100	76						

Student Code ______MI_____________ Total Minutes _______720__________

RH Program (#items)	D	S	%	D	S	%	D	S	%
Short Vowels- 1 (50)	3/23	1000	88	4/11	500	92	5/2	300	92
Short Vowels- 2 (50)	3/23	1000	84	4/11	500	74	5/2	250	92
Short Vowels- 3 (52)	3/23	1000	92	4/11	500	87	5/2	250	81
Short Vowels- 4 (52)	3/23	1000	85	4/11	500	87	5/2	250	87
Short Vowels- 5 (52)	3/23	1000	85	4/11	500	81	5/9	250	88
Related Words 1(31)	4/11	500	94	4/12	500	87	5/9	250	97
Phrases 1 (25)	3/23	1000	<70	4/11	500	72	5/9	400	<70
H V I words- 1 (51)	3/23	1000	96	4/11	300	94	5/9	250	96
Vce pattern- 1 (52)	3/23	1000	73	4/11	300	92	5/9	250	73
Vce pattern- 2 (52)	3/23	1000	<70	3/24	1000	81	5/9	200	<70
Vce pattern- 3 (52)	3/24	1000	98	4/12	500	81	5/9	200	85
Vce pattern- 4 (28)	3/24	1000	96	4/12	500	86	5/9	200	82
Con. Blends- reg (56)	3/24	1000	73	4/12	500	73	5/9	200	<70
Related Words 2(50)	4/12	500	84	4/14	500	90	5/9	200	84
H V I words- 2 (51)	3/24	1000	94	4/14	500	98	5/11	200	94
Phrases 2 (33)	3/24	2000	88	4/14	500	<70	5/11	1000	<70
Reg long e patt. (51)	3/24	1000	98	4/14	500	90	5/11	200	84
Reg long a patt. (38)	3/24	1000	100	4/14	500	82	5/11	200	79
Reg long o patt. (40)	3/25	1000	100	4/14	500	<70	5/11	200	73
Reg long i patt. (22)	3/25	1000	100	4/18	500	77	5/11	200	77
Suffixes (61)	3/25	1000	100	4/18	500	<70	5/11	300	<70
Phrases 3 (52)	3/29	1000	77	4/15	800	<70	5/11	900	73
Related Words 3(33)	3/29	1000	100	4/15	500	82	5/11	200	<70
H V I words- 3 (51)	3/29	900	84	4/18	500	82	5/11	200	75
VR patterns (66)	3/29	900	88	4/18	500	86	5/13	200	76
Diphthongs (57)	3/30	100	<70	4/18	600	77	5/13	200	<70
Con. Blends- irr (81)	3/30	1000	<70	4/18	600	72	5/13	200	<70
Phrases 4 (50)	3/30	1000	76	3/31	NR	74	5/13	900	82
H V I words- 4 (51)	3/31	1000	98	4/19	600	94	5/13	200	90
Final Stable Syl 1(74)	3/31	NR	<70	4/19	600	82			
Final Stable Syl 2(63)	4/4	1000	75	4/19	600	86			
Final Stable Syl 3(54)	4/4	1000	<70	4/19	600	<70			
Irreg vowel patt.(52)	4/4	1000	81	5/2	500	94			
Related Words 4(36)	4/5	1000	83	5/2	500	83			
Phrases 5 (50)	4/5	NR	74	5/2	800	72			
Related Words 5(34)	4/5	NR	88	5/2	500	85			
Prefixes (46)	4/5	NR	<70	5/2	500	<70			

Student Code_______MN_________ Total Minutes _____1440___________

LHLesson (#items)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V-1 (50)	3/23	950	98	4/11	300	100	5/2	200	98	5/13	150	98	5/17	75	96	5/18	65	100
Short V-2 (50)	3/23	950	100	4/11	300	100	5/2	200	100	5/13	150	96	5/17	75	98	5/18	65	100
Short V-3 (52)	3/23	950	98	4/11	250	98	5/2	200	96	5/13	150	95	5/17	75	93	5/18	65	96
Short V-4 (52)	3/23	950	100	4/12	250	100	5/2	200	100	513	150	98	5/17	75	94	5/18	65	100
Short V-5 (52)	3/23	950	100	4/12	250	100	5/3	150	100	5/13	150	98	5/17	75	98	5/18	65	98
Phrases 1 (25)	3/23	2000	100	4/12	600	100	5/3	250	92	5/16	250	92	5/17	180	100	5/18	110	92
Phrases 2 (33)	3/24	NR	94	4/12	500	94	5/3	250	94	5/16	65	88	5/17	180	79	5/18	110	76
Vce patt-1 (49)	3/24	NR	96	4/12	250	100	5/3	150	100	5/16	125	90	5/17	75	88	5/18	65	96
Vce patt-2 (52)	3/24	NR	87	4/12	200	90	5/3	150	94	5/16	125	96	5/17	75	80	5/18	65	88
Vce patt-3 (52)	3/24	NR	92	4/12	250	92	5/3	150	98	5/16	125	98	5/17	75	87	5/18	65	95
Vce patt-4 (28)	3/28	900	96	4/12	250	96	5/3	150	100	5/16	125	89	5/17	75	82	5/18	65	93
Con Bld-reg. (56)	3/28	900	100	4/13	200	96	5/3	150	95	5/16	125	95	5/17	75	95	5/18	65	100
Phrases 3 (52)	3/28	1900	100	4/13	500	94	5/3	250	96	5/16	200	90	5/17	190	88	5/18	180	96
Phrases 4 (50)	3/28	1800	98	4/13	500	100	5/4	250	100	5/16	200	92	5/17	190	86	5/18	180	86
Reg long e (52)	3/28	800	100	4/13	800	98	5/4	100	94	5/16	75	96	5/17	70	96	5/18	65	96
Reg long a (50)	3/28	700	100	4/13	250	100	5/4	100	98	5/16	75	92	5/17	70	98	5/18	65	94
Reg long o (42)	3/29	700	90	4/13	250	90	5/4	100	93	5/16	75	95	5/17	70	90	5/18	45	95
Reg long I (26)	3/29	600	100	4/13	250	100	5/4	100	96	5/16	75	92	5/17	70	88	5/18	65	88
Suffixes (60)	3/29	600	93	4/13	250	90	5/4	100	88	5/16	75	82	5/17	70	85	5/18	65	87
Phrases 5	3/	120	96	4/	50	94	5/	25	88	5/	20	8	5/	18	90	5/	11	88

(50)	29	0		14	0		6	0		16	0	8	17	0		18	0	
VR pat (67)	3/29	600	97	4/14	500	100	5/6	150	99	5/16	75	94	5/17	70	97	5/18	60	99
Diphthongs (58)	3/29	600	98	4/14	500	98	5/6	150	100	5/16	75	96	5/17	70	98	5/18	60	96
Con.Bld.-irr (81)	3/30	600	94	4/14	400	96	5/6	150	92	5/16	75	85	5/17	70	94	5/18	60	90
Phrases-3sw (25)	3/30	1000	100	4/14	400	88	5/6	150	88	5/16	125	84	5/17	180	96	5/18	110	92
Irr. Long a (21)	3/30	500	81	4/15	400	81	5/10	100	<70	5/16	75	71	5/17	70	71	5/18	60	81
Irr. Long e (51)	3/30	500	92	4/26	250	96	5/10	100	92	5/16	75	88	5/17	70	88	5/19	60	96
Irreg. cons(80)	3/30	400	95	4/26	250	93	5/6	150	89	5/16	75	89	5/17	70	89	5/19	60	93
Phrases-4sw (25)	3/30	800	92	4/26	300	96	5/10	150	96	5/16	125	84	5/18	110	88	5/19	100	88
F S S- 1 (74)	3/30	400	96	4/26	250	96	5/10	100	91	5/16	75	80	5/18	65	89	5/19	60	95
F S S- 2 (66)	3/31	NR	95	4/26	250	95	5/10	100	94	5/16	75	89	5/18	65	94	5/19	60	95
F S S- 3 (53)	3/31	NR	91	5/2	250	82	5/10	100	82	5/16	80	85	5/18	65	91	5/19	60	91
Phrases-5sw (25)	4/11	1000	100	5/2	250	96	5/10	150	100	5/18	110	96	5/19	100	92	5/20	85	100
Irr. Vow (57)	4/11	400	100	5/2	250	100	5/10	100	93	5/18	65	95	5/19	60	96	5/20	45	98
Prefixes (49)	4/11	400	96	5/2	250	96	5/10	100	98	5/18	65	96	5/19	60	92	5/20	55	90

Student Code______MN-2__________ Total Minutes ________________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	5/19	50	92	5/20	45	98	5/23	40	98
Short V- 2 (50)	5/19	50	100	5/20	45	100	5/23	40	92
Short V- 3 (52)	5/19	50	93	5/20	45	98	5/23	40	94
Short V- 4 (52)	5/19	50	100	5/20	45	94	5/23	40	100
Short V- 5 (52)	5/19	50	98	5/20	45	95	5/23	40	92
Phrases 1 (25)	5/19	80	92	5/20	65	96	5/23	40	88
Phrases 2 (33)	5/19	80	76	5/20	65	82	5/23	60	91
Vce patt- 1 (49)	5/19	50	90	5/20	45	100	5/23	40	96
Vce patt- 2 (52)	5/19	50	90	5/20	45	94	5/23	40	94
Vce patt- 3 (52)	5/19	50	93	5/20	45	94	5/23	40	91
Vce patt- 4 (28)	5/19	50	89	5/20	45	93	5/23	40	89
Con Bld- reg. (56)	5/19	50	90	5/20	45	97	5/23	40	95
Phrases 3 (52)	5/19	80	90	5/20	65	92	5/23	55	92
Phrases 4 (50)	5/19	80	86	5/20	65	86	5/23	55	92
Reg long e pat (52)	5/19	50	88	5/20	45	98	5/23	40	94
Reg long a pat (50)	5/20	45	92	5/23	40	94			
Reg long o pat (42)	5/20	45	100	5/23	40	97			
Reg long I pat (26)	5/20	45	96	5/23	40	92			
Suffixes (60)	5/20	45	90	5/23	40	88			
Phrases 5 (50)	5/20	85	92						
VR patterns (67)	5/20	45	100						
Diphthongs (58)	5/20	45	100						
Con. Blends-irr(81)									
Phrases- 3sw (25)									
Irr. long a patt (21)									
Irr. long e patt (51)	5/20	55	94						
Irreg. conson. (80)	5/20	55	94						
Phrases- 4sw (25)	5/20	85	84						
F S S- 1 (74)	5/20	55	89						
F S S- 2 (66)	5/20	55	92						
F S S- 3 (53)	5/20	55	91	5/23	50	98			
Phrases- 5sw (25)	5/23	75	100						
Irr. vowel patt (57)	5/23	40	96						
Prefixes (49)	5/23	40	92	4/13	500	100			

Student Code _______PC____________ Total Minutes _______1440__________

RH Program (#items)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V 1 (50)	2/22	2000	100	2/24	800	100	3/10	250	100	4/15	150	100	5/6	110	96	5/11	100	100
Short V 2 (50)	2/23	900	100	2/24	800	100	3/10	250	100	4/27	175	100	5/6	150	100	5/22	90	100
Short V- 3 (52)	2/23	900	100	2/24	800	100	3/10	700	100	3/29	200	98	4/27	175	92	5/6	150	100
Short V- 4 (52)	2/23	900	100	2/24	800	100	2/28	700	100	3/29	200	94	4/27	175	96	5/6	150	96
Short V - 5 (52)	2/28	800	100	3/29	400	98	4/6	250	100	5/6	150	98	5/14	110	100	5/22	90	100
RelWord 1(31)	3/29	600	97	4/6	250	100	5/6	150	100									
Phrases 1 (25)	2/28	1200	100	3/29	800	92	4/6	250	92	5/9	175	85	5/14	150	96	5/22	100	96
H VIword 1 (51)	3/1	800	94	3/2	700	100	3/4	800	100	5/9	175	100	5/14	140	100	5/22	100	100
Vce patt-1 (52)	3/1	800	94	3/2	700	100	3/9	175	100	4/7	250	100	5/14	150	100	5/22	100	100
Vce patt-2 (52)	3/1	800	96	3/2	700	100	4/7	250	100	5/9	175	98	5/15	110	100	5/24	75	98
Vce patt-3 (52)	3/1	800	96	3/3	700	100	3/7	300	100	5/9	175	100	5/15	110	100	5/24	75	96
Vce patt-4 (28)	3/1	800	96	3/3	700	96	3/7	300	100	5/9	175	100	5/15	110	100	5/24	75	100
Con. Bl-reg (56)	3/3	800	100	3/7	300	100	3/28	250	100	5/9	150	100	5/24	100	91			
RelWord 2 (50)	3/10	800	94	4/7	400	100	4/12	250	100	5/9	150	98	5/25	100	100			
H VI wor 2 (51)	3/10	300	100	3/24	250	98	3/28	150	100	5/9	150	100	5/24	75	100			
Phrases 2 (33)	3/4	1000	97	3/7	750	100	3/4	600	100	4/12	400	100	5/9	300	94	5/15	175	94
Reg long epat(51)	3/4	800	100	3/7	500	100	3/21	250	100	4/12	175	100	5/9	150	100	5/17	120	100
Reg long a pat(38)	3/4	800	100	3/10	300	100	3/21	250	100	4/12	175	100	5/9	150	97	5/17	120	100

Reg long opat (40)	3/4	800	93	3/10	300	100	3/23	250	100	4/12	175	100	5/14	150	100	5/17	120	100
Reg long i pat (22)	3/10	300	100	3/23	250	100	3/28	150	100	4/12	100	95	5/10	100	100	5/17	75	100
Suffixes (61)	3/23	400	100	3/24	250	90	3/25	150	100	5/10	110	100	5/17	80	95	5/25	50	98
Phrases 3 (52)	3/24	800	94	3/28	600	100	3/31	400	94	4/27	250	96	5/9	200	86	5/17	175	94
Rel Wor 3 (33)	3/30	800	100	3/31	400	100	4/27	250	100	5/11	110	100	5/18	100	100			
H VIword 3 (51)	3/24	800	96	3/28	600	100	3/31	250	98	4/29	250	100	5/13	175	100	5/19	100	100
VR patt (66)	3/25	500	100	3/30	300	100	3/31	150	97	4/29	250	100	5/19	100	100			
Diphthongs (57)	3/25	500	100	3/30	300	98	4/4	200	100	4/29	250	98	5/18	100	100	5/20	90	100
Con. Bl irr (81)	3/25	500	99	4/4	200	99	4/25	175	98	5/2	150	99	5/20	90	99			
Phrases 4 (50)	3/25	1000	100	3/25	600	98	4/4	500	100	4/14	250	98	5/20	200	96	5/21	175	98
H V Iwor 4 (51)	3/21	250	100	3/23	250	100	4/4	150	100	5/2	100	100	5/21	90	100			
F S S 1 (74)	4/1	800	100	4/8	500	96	4/14	250	100	5/2	175	100	5/21	90	97			
F S S 2 (63)	4/1	800	100	4/8	500	98	4/14	250	100	5/3	175	100	5/21	90	97			
F S S 3 (54)	4/1	1000	70	4/8	800	75	4/14	400	85	4/26	250	89	5/3	175	85	5/21	100	98
Irr vow patt.(52)	4/5	800	96	4/8	500	96	4/15	250	98	5/3	175	96	5/21	100	100			
RelWord 4 (36)	3/25	500	100	4/15	250	97	4/19	175	100	5/3	150	100	5/21	100	97			
Phrases 5 (50)	4/5	1200	98	4/15	800	96	4/19	400	92	4/26	250	94	5/3	200	96	5/22	150	92
RelWord 5 (34)	4/5	800	91	4/15	600	100	4/19	300	100	4/26	200	100						
Prefixes (46)	4/5	800	96	4/15	600	96	4/19	400	100	4/26	250	98	5/22	100	98			

Student Code ________PC con't.___________ Total Minutes _________________

RH Program (#items)	D	S	%	D	S	%
Short Vowels- 1 (50)						
Short Vowels- 2 (50)						
Short Vowels- 3 (52)	5/22	90	98			
Short Vowels- 4 (52)	5/14	110	98			
Short Vowels- 5 (52)						
Related Words 1(31)						
Phrases 1 (25)						
H V I words- 1 (51)						
Vce pattern- 1 (52)						
Vce pattern- 2 (52)						
Vce pattern- 3 (52)						
Vce pattern- 4 (28)						
Con. Blends- reg (56)						
Related Words 2(50)						
H V I words- 2 (51)						
Phrases 2 (33)	5/25	125	88			
Reg long e patt. (51)	5/25	75	98			
Reg long a patt. (38)	5/25	75	97			
Reg long o patt. (40)	5/25	75	98			
Reg long i patt. (22)	5/25	50	100			
Suffixes (61)						
Phrases 3 (52)	5/25	125	92			
Related Words 3(33)						
H V I words- 3 (51)						
VR patterns (66)						
Diphthongs (57)						
Con. Blends- irr (81)						
Phrases 4 (50)						
H V I words- 4 (51)						
Final Stable Syl 1(74)						
Final Stable Syl 2(63)						
Final Stable Syl 3(54)						
Irreg vowel patt.(52)						
Related Words 4(36)						
Phrases 5 (50)						
Related Words 5(34)						
Prefixes (46)						

Student Code______PE__________ Total Minutes ______1440__________

LHLesson(#item)	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	2/23	2000	88	2/24	1900	88	3/22	400	94	4/6	400	88	4/25	300	94	5/3	250	98
Short V- 2 (50)	2/23	2000	70	2/24	1900	82	2/28	1200	92	4/6	300	70	4/25	400	92	5/3	250	94
Short V- 3 (52)	2/28	1200	89	3/2	1200	89	3/22	400	96	4/14	250	96	4/26	250	94	5/3	250	96
Short V- 4 (52)	3/1	1200	79	3/2	1200	81	3/3	1200	89	3/30	600	96	4/14	400	96	4/25	350	92
Short V- 5 (52)	3/2	1200	91	3/3	1200	87	3/7	800	92	3/30	400	96	4/15	250	87	4/26	250	94
Phrases 1 (25)	3/1	3000	76	3/2	2500	84	3/3	250	96	3/22	1000	100	4/15	500	<70	4/26	400	92
Phrases 2 (33)	3/1	3500	<70	3/2	2500	<70	3/3	2500	94	3/22	1000	91	4/15	500	<70	4/26	500	76
Vce patt- 1 (49)	3/3	1200	90	3/10	800	82	3/22	400	90	4/15	300	78	5/6	250	<70	5/11	200	86
Vce patt- 2 (52)	3/4	1200	<70	3/10	800	88	3/22	400	88	4/18	250	<70	5/6	250	80	5/11	200	90
Vce patt- 3 (52)	3/1	1350	72	3/4	1200	88	3/7	800	92	3/30	400	78	4/15	250	77	5/6	200	80
Vce patt- 4 (28)	3/3	1500	<70	3/4	1200	71	3/10	NR	71	4/7	600	89	4/15	250	<70	5/6	300	89
Con Bld-reg(56)	3/4	1200	<70	3/10	800	<70	3/22	700	78	3/30	400	87	4/15	300	<70	5/6	300	80
Phrases 3 (52)	3/10	1600	90	3/22	1400	94	3/23	110	96	3/29	800	96	4/15	600	<70	5/9	600	98
Phrases 4 (50)	3/23	1800	86	3/24	1200	98	3/29	100	96	4/7	700	94	4/27	500	94	5/9	400	96
Reg long e (52)	3/23	110	96	3/24	800	94	3/28	600	96	4/27	400	88	5/9	300	84	5/16	250	92
Reg long a (50)	3/24	800	86	3/28	600	76	3/29	400	88	4/27	300	86	5/9	250	92	5/16	200	74
Reg long o (42)	3/23	110	<70	3/24	800	88	3/28	700	88	4/7	400	93	4/27	300	98	5/9	250	76
Reg long I (26)	3/25	100	88	3/28	700	92	4/7	400	88	4/27	300	92	5/9	250	73	5/16	200	88

Suffixes (60)	3/25	1000	<70	3/31	700	78	4/7	400	87	4/29	350	<70	5/9	400	<70	5/17	250	72
Phrases 5 (50)	3/25	2000	<70	3/31	170	92	4/7	1600	80	4/25	1400	94	4/29	1200	76	5/2	900	94
VR patterns (67)	DNA																	
Diphthongs (58)	DNA																	
Con. Blds.irr(81)	DNA																	
Phrases-3sw(25)	4/5	1200	96	4/12	800	100	4/19	400	100	4/29	300	<70	5/9	250	75	5/16	250	100
Irr. long a (21)	4/5	800	76	4/19	600	81	4/25	400	<70	5/2	250	<70	5/9	250	<70	5/17	250	81
Irr. long e (51)	DNA																	
Irreg. cons (80)	DNA																	
Phrases-4sw(25)	3/25	800	<70	4/8	500	92	4/12	400	100	4/19	250	92	5/2	250	100	5/10	250	92
F S S- 1 (74)	DNA																	
F S S- 2 (66)	DNA																	
F S S- 3 (53)	DNA																	
Phrases-5sw(25)	4/6	800	<70	4/8	500	92	4/19	250	84	5/2	250	100	5/10	250	96	5/18	175	100
Irr. vowel (57)	DNA																	
Prefixes (49)	DNA																	

Student Code_______PE2_________ Total Minutes _________________

LH Lesson (#items)	D	S	%	D	S	%	D	S	%	D	S	%
Short V- 1 (50)	5/10	200	94	5/18	175	96	5/23	150	80			
Short V- 2 (50)	5/10	200	92	5/18	175	90	5/23	150	82			
Short V- 3 (52)	5/10	200	94	5/18	175	96	5/23	150	87			
Short V- 4 (52)	5/2	250	98	5/10	200	80	5/18	175	92	5/23	150	87
Short V- 5 (52)	5/9	200	90	5/18	175	96	5/23	150	83			
Phrases 1 (25)	5/10	300	75	5/19	250	<70	5/23	225	72			
Phrases 2 (33)	5/10	300	<70	5/18	250	<70	5/23	225	<70			
Vce patt- 1 (49)	5/18	175	90	5/19	150	88	5/23	150	80			
Vce patt- 2 (52)	5/18	175	75	5/19	150	88	5/23	125	73			
Vce patt- 3 (52)	5/11	190	92	5/18	150	90	5/19	150	88	5/23	125	83
Vce patt- 4 (28)	5/16	250	93	5/18	150	89	5/19	150	89	5/23	125	82
Con Bld- reg. (56)	5/16	250	85	5/18	150	<70	5/23	150	75			
Phrases 3 (52)	5/16	550	96	5/19	500	87						
Phrases 4 (50)	5/9	400	96	5/16	300	80	5/19	350	<70			
Reg long e pat (52)	5/18	150	80									
Reg long a pat (50)	5/18	150	80									
Reg long o pat (42)	5/16	200	74	5/18	150	81						
Reg long I pat (26)	5/18	150	85									
Suffixes (60)	5/23	200	<70									
Phrases 5 (50)	5/9	750	<70	5/23	700	<70						
VR patterns (67)												
Diphthongs (58)												
Con. Blends-irr(81)												
Phrases- 3sw (25)	5/23	200	75									
Irr. long a patt (21)	5/23	200	71									
Irr. long e patt (51)												
Irreg. conson. (80)												
Phrases- 4sw (25)	5/17	250	96	5/23	200	76						
F S S- 1 (74)												
F S S- 2 (66)												
F S S- 3 (53)												
Phrases- 5sw (25)	5/23	150	72									
Irr. vowel patt (57)												
Prefixes (49)												