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A Neuroeducation Description of a Paradigm Shift in Identification, Assessment, and
Treatment of Suspected Childhood Apraxia of Speech with Supporting Evidence
Through Interview and Artifact Analysis Provided by Speech Language Pathologists
and Educators

by

Jessica L. Duffett

A dissertation submitted in partial fulfillment
of the requirements for the degree of

Doctor of Education
in
Learning and Leading

University of Portland
School of Education

2016

Abstract

The purpose of this study was twofold. First, the study explored the pertinent cognitive psychology, neuroscience, and language literature that surrounds the diagnosis and treatment of children with Suspected Childhood Apraxia of Speech (sCAS) with the intent of finding a translational neuroeducation approach to the treatment of sCAS. The results of this literature suggest that the surface problems- phonology, morphology, syntax- are mapped onto a semantic basis. This semantic basis is feature based and people with speech sound disorders are likely to use a visual semantic feature basis. So, the literature supports a shift to a new lens that aligns with the Neurosemantic Language Learning Theory (NLLT) and that could be the basis for intervention in sCAS. Second, while traditional treatment is aimed at the acoustic motor patterns of phonological processes, this study sought to uncover what professionals who have some neuroeducation training say they do when they treat children with sCAS. Interviews were conducted with sixteen Speech Language Pathologists (SLPs) and Educators currently using principles of neuroeducation to treat children with sCAS in order to uncover the methods that they report having used in interventions with this population. It was found that both SLPs and educators who use methods of assessment and intervention based on the NLLT reported positive outcomes for intelligibility and language function. The respondents also reported using intervention methods that align with the NLLT to a high degree. The interviews, along

with artifacts provided by interview participants, served as confirmatory evidence to the findings from the literature review by demonstrating the reported change in children over time as a result of the intervention. Additional themes were found around definitions of sCAS, intervention methods and alignment of diagnostic criterion, philosophy and intervention methods among interviewees.

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Last but not least, I express my gratitude to my Father in Heaven for setting my feet on this path and sustaining me through it. In and through the enabling power of the atonement of Jesus Christ, I have been able to do better work and have become better as a result of this process.

Dedication

This dissertation is dedicated to all of the children with whom I have worked and will work. Thank you for your contribution to my understanding of language, learning and communication disorders. I hope that I will serve you better as a result of the learning

I have undertaken in completing this dissertation.

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Chapter One: Introduction to the Study

Suspected Childhood Apraxia of Speech (sCAS) is a communication disorder that impacts the motor programming, planning and phonological systems and results in impaired intelligibility (ASHA, 2007¹). It can result from neurological trauma or be idiopathic in nature, having an unknown cause (ASHA, 2007¹). To date, there has been relatively little research in the area of sCAS, stemming partly from a lack of coherent definition of the diagnostic criteria (Kent, 2000; Lewis et al., 2004). Whereas current intervention methods in sCAS center around remediating the perception, motor production and/ or phonological representations of children with the disorder, this dissertation takes a neuroeducation approach. Specifically, the dissertation asks how the literature in neuroscience, cognitive psychology and language contributes to definitions of, assessment and interventions in sCAS. It then provides a triangulation of the literature in these contributing fields to suggest a new approach to sCAS. Finally, based on the implications of the triangulation of literature, the study asks Speech Language Pathologists and Educators who report using methods based on neuroeducation what it is that they do when they intervene with children with sCAS or other speech sound disorders.

Background of the Problem

According to the definitions of speech and language given by the American Speech-Language Hearing Association, sCAS falls into the categories of both a speech and a language disorder. As a speech disorder, sCAS affects the way that children produce syllables and words (ASHA, 2007⁴). As a language disorder, sCAS affects the

phonological system which refers to the rules that govern sound systems, a component of language in ASHA's definition (ASHA, 1993; 2007⁵). Interventions that focus on sCAS as a speech disorder target the patterns arising from the phonological system (Costello, 1975; Hodson, 2011; Williams, 2012). On the other hand, interventions that focus on sCAS as a language disorder, target lexical representations at the word level (Pinnow & Connine, 2014; Storkel & Morrisette, 2002), but do not consider the process of language acquisition. Therefore the current state-of-the-art in sCAS primarily considers the sound system of words but not the whole semantic system, a problem which this study identifies and addresses. The following subsection will take the reader through a brief background regarding definitions and diagnostic criterion in sCAS, demonstrating that a lack of definitional consensus yields variable criteria for intervention studies. Following the discussion of definitions, an assessment and intervention subsection will briefly review the literature that deals with outcomes in sCAS and point to a gap in literature that demonstrates a need for a greater semantic basis to intervention in sCAS. A third subsection will contain a treatment of linguistic theories which provide support for the semantic basis of treatment and language as an acquisition process. Following these subsections, which parallel the literature review in Chapter Two, the reader will have an understanding of the scope of the background literature supporting the problem statement.

Definitions of sCAS. Suspected childhood apraxia of speech (sCAS) is a motor speech disorder affecting children during development of the language system.

It can be idiopathic in nature or have a neurological or neurobehavioral etiology (ASHA, 2007¹). First described by Yoss and Darley in 1974, sCAS has been documented by numerous researchers without yielding a consensus on the diagnostic criteria (Kent, 2000; Lewis et al., 2004). Definitions surrounding sCAS deal with articulatory slowness, abnormal scaling of articulatory gestures, variability of speech production, and segmentalization (Weismer, Tjaden, & Kent, 1995); articulatory slowness and abnormal scaling of articulatory gestures (Browman & Goldstein, 1989; Weismer et al., 1995); segmental and suprasegmental features (ASHA, 2007¹); rates of diadochokinesis (a measure of how quickly a person accurately repeats rapid, alternating phonetic sounds), omissions, revisions and additions in productions, feature errors such as phoneme prolongations, repetitions and distortions and non-speech characteristics including difficulty performing volitional oral movement (Yoss & Darley, 1974). The definition given by the American Speech Language Hearing Association (ASHA) on [suspected] Childhood Apraxia of Speech is

Childhood apraxia of speech (CAS) is a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone). CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral disorders of known or unknown origin, or as an idiopathic neurogenic speech sound disorder. The core impairment in planning and/or programming

spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody (ASHA, 2007¹).

While definitions of sCAS vary, according to Lewis and colleagues (2004): “The most commonly reported characteristics are difficulties sequencing phonemes and syllables, trial and error groping behaviors, and inconsistency in articulation with unusual error forms on both consonants and vowels” (p. 159). Both theories of articulation and theories of phonological disorder contribute to the literature in sCAS. The articulation theories of sCAS, especially as demonstrated in non-speech movement disorders (Yoss & Darley, 1974) suggest a purely motoric etiology. Literature in the area of phonology, however, suggests the motor difficulties seen in sCAS at the planning or programming level stem from a faulty phonological representation; the mental representation of the sounds and sound combinations stored in memory that comprise the spoken words used to represent ideas or concepts (Claessen & Leita, 2012). There are competing theories of how the processing of sound and language affect sCAS. For instance the phonological theory of sCAS suggests that lower level information affects higher levels of processing in the brain (Moriarty and Gillon, 2006). By contrast, neuroscience literature suggests that information is processed hierarchically in auditory pathways and that higher-level linguistic information will mediate lower-level information (Zhang et al., 2011). The difference is a bottom up versus a top down processing approach.

Imaging studies show that people with speech sound disorders experience a lack of temporal synchrony in the auditory cortex of the brain because visual and

acoustic inputs are not able to be processed simultaneously (Stevenson, VanDerKlok, Pisoni, & James, 2011). Asynchrony in the temporal lobe, leading to a lack of integration of the audio-visual speech signal, can result in phonological errors that are seen in sCAS.

Neuroimaging also demonstrates that phonemic confusion, which is evident in faulty phonological representations, occurs in the auditory lobes bilaterally in the absence of motor cortex involvement (Arsenault & Buchsbaum, 2015). This literature supplies functional and structural explanations for the difficulty in perceiving and manipulating speech sounds, naming differences in the auditory lobes of the brain.

Finally, although sCAS is not generally thought of as a hereditary disorder there is some evidence for a genetic component to sCAS as evidenced in a multigenerational family with sCAS expression who all demonstrate an underlying transcription in the FOXP2 gene (Lai, Fisher, Hurst, Vargha-Khadem, & Monaco, 2001; Lai, Gerrelli, Monaco, Fisher, & Copp, 2003; Lewis, et al., 2004). In sum, sCAS remains a nebulous diagnosis in the communication sciences and disorders due to the lack of agreement in the research literature regarding diagnostic criteria that separate sCAS from other speech sound, motoric or language-based disorders such as articulation disorders and phonological disorders, respectively.

Assessment and interventions. Due to a lack of consensus on diagnostic criteria there are currently no valid and reliable assessment instruments for the diagnosis of sCAS. Suspected Childhood Apraxia of Speech meets ASHA's criteria both as a speech sound disorder with motoric origins and as a language disorder

resulting from a disorder in phonological processing (ASHA, 2007⁴). As a speech-sound disorder, intervention in sCAS focuses on isolating and treating the patterns that are thought to be a product of the phonological system through such varied treatment methodologies as Sound Contrasts in Phonology (SCIP), Hodson Phonological Cycles, Minimal Pairs and others (Hodson, 2011; Williams, 2012). Manipulation of the distinctive features of sounds attempt to change how the brain processes the acoustic wave by targeting those features which are in error across patterns of phoneme production for remediation (Costello, 1975; Costello & Onstine, 1976). In contrast, language approaches to sCAS as a speech sound disorder draw on theories of lexical processing in which the word is the meaningful unit of analysis and acquisition (Pinnow & Connine, 2014) and attempt to isolate treatment targets (words) through consideration of neighborhood density of words and phonotactic probability, both of which yield a great deal of similarity of sound (Storkel & Morrisette, 2002). Very little information is available in the literature that considers sCAS as a language disorder although it has been established through the ASHA definitions that sCAS is both a speech and a language disorder. This appears to be because in the scientific research literature, language is described in terms of the surface structures, which are the syntactical forms that concepts take as actual sentences (Chomsky, 1969) and not in terms of linguistic function to name and refine concepts. The support for sCAS as a sound-based language disorder comes from the available literature that suggests language disorders are connected to disruptions in the phonological system, evidenced through altered speech patterns, and that language learning disorders result from

phonological deficits rather than cognitive or linguistic impairments (Tallal, et al., 1996).

Based on the assertion that a phonological deficit rather than a cognitive or linguistic impairment is at the heart of language learning disorders, and that children with language learning impairments experience difficulty in processing the rapidly changing sensory inputs of the acoustic wave; Tallal et al. (1996) and Merzenich and colleagues (1996) have studied the effects of temporal modification of the acoustic wave. While studies show that the brain can be trained to recognize the properties of the acoustic waveform, underlying semantic meaning for conceptualization is missing (Merzenich et al., 1996; Tallal et al., 1996).

Literature in neuroscience lays a foundation for alternatives to lexical and phonological system intervention. Neuroscience literature supports an evolutionary connection between the use of the hand to create and manipulate tools and the emergence of human speech known as a phylogenetic relationship (Meister, et al., 2003). Studies investigating hand and speech control and oral and hand movement speeds support the supposition of a central mechanism that transcends domains for control of motor movement (Leighton & Hayes, 2010; Meister, 2003; Peter, 2012). Further, imaging studies indicate that the mirror neuron area in the macaque monkey brain corresponds to Broca's area in the human brain which is implicated in matching observation and execution and has mirror neurons that respond both to hand movement and to bucco-laryngeal speech (Arbib & Rizzolatti, 1996). This has implications for intervention, suggesting that intervention in sCAS might benefit from

use of the hand to create language through writing and drawing as an alternative to the traditional focus on the production of sounds from the larynx and mouth.

Based on the all or nothing law of the action potential, a neuron must reach its full action potential in order to fire; it does not fire partially given insufficient activation (Baars & Gage, 2010). Inhibition and integration work in the brain to develop structural groupings of neurons, circuits and networks that function together. The implication for a motor hand-area neuron being increased in its excitability, which means a lowering of the action potential threshold and an increased readiness to fire, is that in this possible two-way connection, movement of the hand could decrease the firing threshold for neurons activated for speech. This becomes particularly important when considering that treatments working on the phonological system yield similarity of sound (Storkel & Morrisette, 2002) and children with sCAS are at a disadvantage for processing sound due to the lack of temporal synchrony (Stevenson et al., 2011).

There appears to be a lack of literature that considers the interaction of the cognitive, linguistic and phonological systems as an integrated whole. Intervention in the area of sCAS is most commonly aimed at the patterns emerging from the phonological system and considers sCAS as a speech sound disorder with origins in phonological deficit and/or motor programming/planning but does not consider sCAS in terms of language function. In the current model, sCAS is defined mostly in terms of the surface structures of language (ASHA, 2007¹; Browman & Goldstein, 1989; Weismer et al., 1995; Yoss & Darley, 1974). The literature review further revealed that sCAS stems from errors of perception (Stevenson, et al., 2011; Tallal et al., 1996;

Yoss & Darley, 1974), phonological representation (Claessen & Leitao, 2012; Eulitz & Lahiri, 2004; Kent, 2000; Moriarty and Gillon, 2006; Shriberg, Aram & Kwiatkowski, 1997) and motor planning (ASHA, 2007²; Weismer et al., 1995; Yoss & Darley, 1974).

The definitions given by the American Speech Language Hearing Association show sCAS to be both a speech disorder as it affects the way children produce syllables and words (ASHA, 2007⁴) and a language disorder as it impacts the phonological system, a component of language in ASHA's definition (ASHA, 2007⁵). Interventions that focus on sCAS as a speech disorder target the patterns arising from the phonological system such as Sound Contrasts in Phonology (Williams, 2012), Hodson Phonological Cycles (Hodson, 2011) and distinctive features based approaches (Costello, 1975). On the other hand, interventions that focus on sCAS as a language disorder target lexical representations at the word level (Pinnow & Connine, 2014; Storkel & Morrisette, 2002). ASHA defines language in terms of form, content and function (ASHA, 2007⁵). The literature review presented in Chapter Two demonstrates that language-based interventions which target the surface structures of language do not consider the deep semantic structures. This reveals a gap in the literature in consideration of sCAS as a language function based disorder.

The following subsection dealing with linguistic theories explores the language to speech relationship in terms of acquisition and intervention. The statement of the problem is then put forth followed by a proposal for a language-based approach to sCAS where speech is the product of disorders present in the acquisition processes.

Linguistic theories. Verbal speech can be viewed as a product of the language acquisition process. Linguistic theorists in the 19th and early 20th centuries asserted that speech is a developmental product which represents the child's development up to the time of the utterance (Arwood, 1983; Lenneberg, 1969). Development, according to these early language theorists, is a product of learning, not a naturally unfolding process (Vygotsky, 1962). Because development is learned, it is important to understand the conditions that best facilitate learning, specifically in reference to acquiring language. Several theorists support the idea that concept acquisition or thinking forms the basis for speech production (Chapman, 2000; Dore, 1979; Lenneberg, 1962). According to Vygotsky "Speech cannot be discovered without thinking" (1962, p. 44). The Neurosemantic Language Learning Theory (NLLT), proposed by Arwood in 1980, also supports this idea. It proposes that children acquire the sensory patterns of acoustic and visual waveforms which are then overlapped to form concepts. The concepts are named with language and it is language that supports speech (Arwood, 2011). In addition to suppositions put forth by 19th and 20th century language theorists, the relationship between language and speech is also supported by neuroscience. The neocortex of the brain is organized into six layers. Cell assemblies pass information up from the brain stem and receive feedback through the dual processes of integration and inhibition (Baars & Gage, 2010). This hierarchical organization is theorized to account for the relationship between speech and language in the brain. Speech as a chaining of sound sequences can be taught at the pattern level which corresponds to subcortical regions of the brain. Language,

which in the NLLT names concepts, corresponds to the networks of cells found in the cortical regions of the brain (Arwood, 2011). Therefore because four times more feedback is provided for each impulse passed upward due to layers of inhibition in the brain, intervention at the language level should impact speech (Baars & Gage, 2010). Theoretically, gains in language should result in improved speech intelligibility.

The question that arises then is how to effect gains in language; what type of input is needed? Each of the receptor organs of the body communicates input through nerve impulses to the brain (Baars & Gage, 2010) but the properties of the sound wave, pitch, frequency and amplitude and the properties of the visual wave, light and movement, are those known to support language (Arwood, 2011). The linguistic sciences have demonstrated that in all of the languages of the world, there are no languages with full grammars that are based only on acoustic patterns (Arwood, 2011). Therefore either acoustic and visual patterns must be overlapped or visual patterns must be overlapped with visual patterns to form concepts for thinking (Arwood, 2011). Neurologically, it has been shown that the ability to simultaneously process inputs from the acoustic and visual waves in the temporal lobe is not present in all brains; specific clinical populations including people with Autism spectrum disorder, schizophrenia and dyslexia have demonstrated structural and functional differences in the superior temporal cortex, the area of the brain thought to be responsible for temporal synchrony (Stevenson et al., 2011). Prior to the technological advances that allow for neuroimaging Yoss and Darley (1974), pioneers in the establishment of sCAS as a diagnostic category, also found disparities in performance

in auditory perception and auditory sequencing ability for children with speech sound disorders compared to age and gender matched controls. Given that overlapping patterns are required for concept acquisition and that children with sCAS are likely to experience a lack of temporal synchrony, alternative inputs to traditional audio-visual speech based on auditory patterns must be considered. One such alternative input is the use of overlapping visual patterns that are meaningful, or semantic, to the learner. In this dissertation, such an intervention is referred to as a semantic-based language intervention. The literature suggests that semantic intervention can include movement of the hand to access language through drawing and writing concepts and their associated grapheme patterns (Arbib & Rizzolatti, 1996). If semantic intervention can increase the firing potential of neurons involved in speech production, then intervention for the acquisition of semantic features in conceptual development might promote fluent verbal speech.

Statement of the Problem

The previous section introduced the NLLT which suggests that the brain acquires semantic features and overlaps patterns of semantic features that align with the individual's neurobiological learning system to form concepts that are then named with language. While the NLLT aligns with the findings of the study presented in Chapter Four, it appears that there currently exists limited literature on the efficacy of a semantic-based language intervention in sCAS. Existing literature surrounding intervention in sCAS deals with the surface structures of language, primarily arising from the phonological system. At least one researcher and his colleagues have

recognized that in the absence of temporal synchrony in the auditory cortex, semantic features of the sound wave cannot be processed correctly and will result in learning delays or disabilities such as speech sound disorders, dyslexia and language impairments (Merzenich, et al, 1996; Tallal et al, 1996). However these researchers failed to take into account that the not all brains are able to utilize multisensory integration of the acoustic and visual information in the temporal auditory lobe (Koelewijn, Bronkhorst, & Theeuwes, 2010). Such individuals report that they don't use sound for thinking but use visual ideas (Arwood, 1991; 2011). Theoretically then, some people must overlap visual features rather than integrate sound and sight features for concept formation. Merzenich (1996) has shown that brains can be trained to recognize the features of the sound wave but without the multisensory integration, some individuals do not form concepts from the trained patterns of acoustic features. This type of training may not result in increased language function or thinking. Therefore there is a need to identify an intervention that yields both increased thinking and language function and that also improves outcomes for intelligibility in children with sCAS.

Purpose of the Study

The purpose of this qualitative research study is twofold: 1) To explore the pertinent cognitive psychology, neuroscience, and language literature that surrounds the diagnosis and treatment of children with Suspected Childhood Apraxia of Speech (sCAS) with the intent of finding a translational neuroeducation approach to the treatment of sCAS and, 2) to uncover what professionals who have some

neuroeducation training say they do when they treat children with sCAS, including their reported outcomes.

Research Questions

This study seeks to determine whether a visual-motor language intervention approach based on properties of visual acquisition of concepts results in improvement in speech and language functioning in suspected childhood apraxia of speech (sCAS). This information is collected from SLPs and educators in school-based or private practice who self-report that they use a neuroeducation paradigm or Viconic Language Methods,TM (VLMs) which are the methods associated with the Neurosemantic Language Learning Theory (NLLT), with children with sCAS or speech sound disorders, respectively. The research questions asked were:

1. Will Speech Language Pathologists (SLPs) and educators with a theoretical background in the NLLT; and, who report using neuroeducation-based methods with their clients, with sCAS or speech sound disorders respectively; also report positive client outcomes for both speech intelligibility and language function?
2. To what degree will Speech Language Pathologists (SLPs) and educators who report using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively report use of methods that align with the NLLT?

Research Design

This research study was undertaken in three parts. The first part, a review of the literature in cognitive psychology, neuroscience, and language was shown to align with the NLLT, is detailed in Chapter Two and the triangulation of literature, an outcome of the literature review, is provided in Chapter Four. The second part of this dissertation was comprised of interviews of SLPs and educators who report using methods based on neuroeducation for treatment of sCAS. The use of interviews as a qualitative tool allowed the researcher to understand the lived experience of a population under study, in this case the experience of SLPs and educators, using an intervention approach not previously reported with efficacy support in the literature. The third part of the study involved evaluating the intervention steps that the interview participants reported to uncover whether there was a semantic basis to the intervention in conjunction with analysis of the artifacts submitted by interview participants.

In order to understand the use of VLMS in the sCAS treatment setting, this researcher interviewed SLPs and educators who self-identify as using Viconic Language MethodsTM. Semi-structured interviews were used with a structured component for collecting demographic information. See Appendix A for a schedule of interview questions. Interviews were then transcribed and an inductive analysis of thirteen interview transcripts was undertaken to uncover themes using NVivo software. See Appendix B for a list of themes. Finally, one or more artifacts was chosen from three interviewee submissions and they were analyzed for evidence of semantic intervention.

Findings

The two research questions dealing with whether the target populations would report positive client outcomes as a result of language-based intervention strategies; and, whether they would also report a paradigm shift in how they regarded speech sound disorders including sCAS were both answered in the affirmative. Specifically, one hundred percent of SLPs and educators who reported using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively reported positive client outcomes for both speech intelligibility and language function. Additionally, all of the SLPs and educators included in the data analysis reported using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively. See Table 4.3 for results. Additional themes were found around definitions of sCAS, intervention methods and alignment of diagnostic criterion, philosophy and intervention methods among interviewees and are reported in Chapter Four.

Student work artifacts from individuals who provided confirmatory information were analyzed for three students between the ages of five and 18. Each artifact demonstrated restricted language function and orthography. Each artifact also revealed the process of adult refinement through the learner's system (Vygotsky, 1962) and the resultant gains in language function and orthography were noted. The impaired phonological system and subsequent impairment in intelligibility were inferred as were resultant gains in speech intelligibility.

Assumptions and Limitations of the Study

While qualitative research can be increasingly valid because there is no instrument standing between the researcher and subject, it can also be subject to threat because of the inherent biases of the researcher-as-instrument (Merriam, 2009). This researcher's biases in this research were as follows: First, the researcher was and continues to be a licensed and certified Speech-language Pathologist and as such approaches the problem of treatment in sCAS from the perspective of an SLP but does not have any formal medical training in diagnosing motor speech disorders. Moreover, due to the researcher's ongoing continuing education, the researcher has developed a long-standing personal belief that language is the vehicle by which all observable behavior can be influenced and changed. Based upon past clinical experience yielding limited treatment outcomes the researcher also harbored a strong distaste for traditional speech sound therapy based on the principles of behaviorism. The researcher was therefore invested in the outcome of this research to show that a language-based intervention is plausible for remediation of speech sound disorders such as those seen in sCAS. This could have led to a tendency to see impact of findings where an unbiased observer might not. These limitations were addressed through supervision from the researcher's Dissertation Chairperson who has more than 45 years of experience in the field of Speech Language Pathology as well as through the use of member checks and alignment of student artifacts with results from interview analyses.

The use of interviews in this study helped to uncover what professionals said that they did in intervention with populations with sCAS or speech sound disorders and analysis of artifacts substantiated their claims. However a limitation of this study was that no interventions in populations with sCAS or speech sound disorders were observed firsthand and no pre- and post-treatment verbal language samples were available for collection. Without verbal language samples, the researcher was left to infer changes in intelligibility based on reports from interviewees and analysis of orthography and language function changes in the analyzed artifacts.

Summary

This chapter provides a background of sCAS as it is situated in the context of speech sound disorders and language disorders. A brief overview of the research presented in Chapter Two is given here, demonstrating a research gap in the assessment and treatment of sCAS as a language disorder. The problem statement and research questions are stated and an overview of the research design and methodology are given, which are expanded on in Chapter Three.

Chapter Two includes a review of the literature. Because no theoretical framework exists currently which encompasses the scope of this research proposal, Chapter Two is organized by providing a background of sCAS then presenting the research in the areas of language, cognitive psychology and neuroscience which align with the precepts of the Neurosemantic Language Learning Theory (NLLT), which forms the basis for the proposed paradigm shift from use of sounds to semantics. Chapter Three details the methods that will be used in the research and includes the

interview schedule that will be used in the semi-structured interviews. Chapter Four gives a summary of results from both interviews and artifact analysis and chapter five contains a discussion of the significance of the findings of this study.

Chapter Two: Review of the Literature

The purpose of this study is twofold: It seeks to explore the pertinent cognitive psychology, neuroscience, and language literature that surrounds the diagnosis and treatment of children with Suspected Childhood Apraxia of Speech (sCAS) with the intent of synthesizing that literature to identify a translational neuroeducation approach to the treatment of sCAS. The second part of the study, the application of the theory seeks to uncover what professionals who have some neuroeducation training say they do when they treat children with sCAS, which will be explored in Chapters Three, Four and Five.

Organization of Chapter Two

This chapter begins by establishing a theoretical framework in neuroeducation. The review of literature specifically looks at sCAS in terms of its definitions, diagnosis and interventions through each of the aforementioned lenses and then shows that the paradigm shift to a neuroeducational lens aligns with the Neuro-semantic Language Learning Theory (NLLT; Arwood, 2011). The literature in neuroscience, cognitive psychology and language is reviewed in three sections relating to sCAS: definitions, assessment and interventions. A research gap showing a lack of literature reported with efficacy for treatment of sCAS from a neuroeducation lens is identified in the area of assessment and intervention in sCAS as a language-based disorder. At this time sCAS is identified as having a basis in both speech and language processes (ASHA, 1993); but, the majority of interventions are based in speech. Finally, literature supporting a language based intervention in sCAS is reviewed. An outcome

of this review will be a suggested paradigm shift to consider sCAS as a language-based disorder, a shift from use of sound to semantics to diagnose and intervene in sCAS.

Theoretical Framework in Neuroeducation

Neuroeducation is a translational discipline tasked with applying findings in contributing fields to the social science of education (Nouri & Mehrmohammadi, 2012). Neuroscience literature contributes information about the structures and functions of the brain and the central nervous system. Cognitive Psychology literature references the study of the mind and the products that come out of it such as thinking, viewing, reading, writing, speaking, listening and calculating (Cooper, 2006). Language, a perspective which is unique and is not commonly considered when applying a neuroeducation lens refers to "...the underlying thinking processes as cognitive functions and the surface forms as imitated structures" (Arwood, 2011, p. 385). Each of the three lenses, cognitive psychology, neuroscience, and language, can be integrated to make effective applications in education. Including language is of particular importance to mitigate biases that adults make with their fully developed language systems, in order to understand how children learn and acquire language. In this chapter a number of theoretical frameworks along with empirical evidence will be put forth for the purpose of establishing a research basis to eliminate the gap between the definition of sCAS being attributed to both speech and language processes with the majority of interventions based only in speech. The research will uncover whether a neuroeducation lens supports a language approach to intervention in sCAS.

Figure 1.1 The Neuroeducation Framework

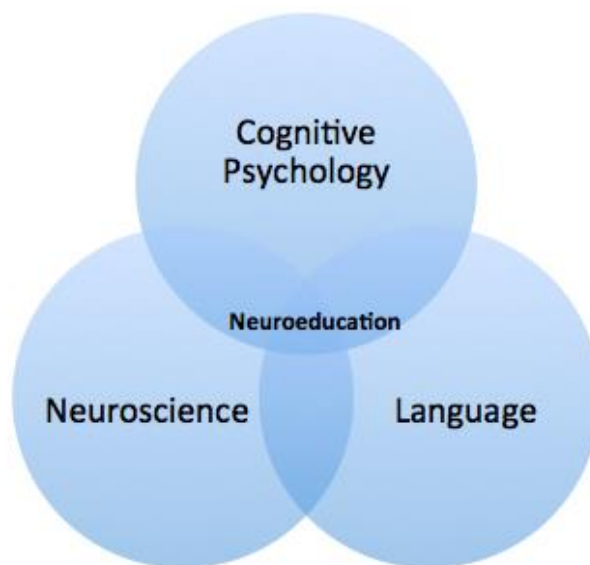


Figure 1.1 The Neuroeducation Framework occurs at the intersection of the cognitive psychology, neuroscience and language lenses

Figure 1.1 The Neuroeducation framework occurs at the intersection of the cognitive psychology, neuroscience and language lenses.

Suspected childhood apraxia of speech will be defined in terms of each of the three contributing fields—neuroscience, cognitive psychology and language—in the first section. A second section sets forth the literature in assessment and intervention in sCAS and shows that although sCAS is defined as both a speech and language disorder, most interventions are based in speech and therefore there is a research gap in interventions in sCAS based on a language, or semantic, function. Stemming from

the research gap, the concluding section frames language theories that contribute to a new paradigm in thinking about and treating sCAS as a language disorder.

Definitions in Suspected Childhood Apraxia of Speech

The fields of Cognitive Psychology, Neuroscience and Language each contribute unique tenets to the definitions of suspected Childhood Apraxia of Speech (sCAS). It is important to consider the contribution of each of these fields, because, each field influences the assessment criteria and intervention methods that are used with this population.

Suspected childhood apraxia of speech is framed within the broader context of communication disorders. A communication disorder is defined as:

an impairment in the ability to receive, send, process, and comprehend concepts or verbal, nonverbal and graphic symbol systems. A communication disorder may be evident in the processes of hearing, language, and/or speech. A communication disorder may range in severity from mild to profound. It may be developmental or acquired. Individuals may demonstrate one or any combination of communication disorders. A communication disorder may result in a primary disability or it may be secondary to other disabilities. (ASHA, 1993).

This American Speech Language Hearing Association (ASHA) document divides communication disorders into two classes: speech disorders and language disorders. Speech disorders are those disorders that result in an impairment of the articulation of speech sounds, fluency or voice while a language disorder is defined as

impaired comprehension or use of spoken, written or other symbolized language systems (ASHA, 1993).

In accordance with the ASHA definitions of speech and language disorders, Childhood Apraxia of Speech (CAS) is a speech disorder that affects the way children produce syllables and words. Affected populations may experience difficulty with planning and producing movements of the tongue, jaws and teeth to form intelligible speech (ASHA, 2007²). First described by Yoss and Darley in 1974, CAS has been documented by numerous researchers without yielding a consensus on the diagnostic criteria (Kent, 2000; Lewis et al., 2004). As a result of the lack of consensus for diagnostic criteria, ASHA suggests that, when considering a diagnosis of CAS, professionals use language such as “consistent with CAS,” “CAS cannot be ruled out” or “suspected CAS” (ASHA, 2007²). For this reason, the term suspected Childhood Apraxia of Speech (sCAS) will be used in the remainder of this chapter. Direct quotations, however, may contain the terms Childhood Apraxia of Speech (CAS), apraxia, developmental apraxia or developmental apraxia of speech.

Suspected Childhood Apraxia of Speech is also known as Developmental Apraxia of Speech and appears in the research literature interchangeably as apraxia and dyspraxia, with the United States being the only English-speaking country to use the term “apraxia.” The preferred terminology for ASHA, which oversees the practice of speech-language pathologists in the United States, is “childhood apraxia of speech” because it encompasses all three possible etiologies whereas the term “developmental”

primarily indicates an idiopathic origin and suggests that CAS may be outgrown (ASHA, 2007¹).

Definitions of sCAS as a speech sound disorder will be dealt with in the cognitive psychology section below. A section on neuroscience follows, which delineates the neurological structures involved in definitions of sCAS. Finally, a language section will address contributions to definitions of sCAS dealing with the phonological system.

Contributions in Cognitive Psychology to Definitions in sCAS

In the field of Speech Language Pathology, speech sound disorder (SSD) is an umbrella term that encompasses difficulties with perception, motor production and/ or phonological representation of speech sounds and segments (including phonotactic rules governing syllable shape, structure, stress and prosody) (ASHA, 2007⁴). Speech sound disorders are further divided into motor-based disorders including apraxia and dysarthria, structurally based disorders such as those resulting from cleft palate or other oro-facial anomalies, syndrome/condition-related disorders such as Down Syndrome, and sensory-based conditions such as hearing impairment (ASHA, 2007⁴).

Cognitive Psychology encompasses the study of the mind and mental processes including aspects such as attention, language use, memory, perception, problem solving, creativity and thinking. It is “the science of how the mind is organized to produce intelligent thought and how it is realized in the brain” (Anderson, 2010, p. 1). The cognitive psychology lens provides definitions of sCAS in

terms of both the articulatory system and the phonological system by analyzing their products as constructs of the mind. Each is discussed below.

Articulation. According to the American Speech Language Hearing Association, speech sound disorders can be classified as being derived from structural or motoric deficits. Disorders that impact the form of speech sounds are traditionally referred to as articulation disorders and are associated with structural (e.g., cleft palate) and motor-based difficulties (e.g., apraxia). (ASHA, 2007⁴).

An articulation disorder “is the atypical production of speech sounds characterized by substitutions, omissions, additions or distortions that may interfere with intelligibility” (ASHA, 1993). Yoss and Darley (1974) identify a continuum of behaviors present in children with sCAS, related to both structural or articulation deficits and motor planning deficits. Children with sCAS may exhibit the following features in speech production: slower than normal rates of oral diadochokinesis (the ability to perform rapidly alternating muscular movements), greater difficulty on polysyllabic words as indicated by omissions, revisions or additions of syllables, two and three-feature errors including prolongations, repetitions, distortions and additions in repeated speech tasks, distortions or one-place feature errors such as additions and omissions in spontaneous speech and altered prosodic features such as slowed rate and equalized stress.

In addition to affecting speech structures resulting in articulatory errors, sCAS is a motor speech disorder affecting children during development of the language system as a full adult grammar is not realized until about seven to eight years of age

(Arwood, 2011). Suspected childhood apraxia of speech (sCAS) can be idiopathic in nature, having an unknown cause, or have a neurological or neurobehavioral etiology (ASHA, 2007¹). A genetic link in sCAS will be discussed in the neuroscience definitions section below. Suspected Childhood Apraxia of Speech differs from adult-onset apraxia, which typically occurs as the result of a neurological insult such as a cerebral infarction or traumatic brain injury.

Research surrounding adult acquired Apraxia of Speech (AOS) demonstrates a consensus that the deficit that exists is specifically a motor programming deficit related to the planning rather than the execution phase of speech output (Weismer et al., 1995). In contrast, literature in the area of sCAS has not demonstrated a consensus about whether the deficit that affects the grouping of behaviors diagnostically indicated for sCAS occurs at the planning and programming or execution phase. Shared characteristics of motor speech disorders include articulatory slowness, abnormal scaling of articulatory gestures, variability of speech production and segmentalization (Weismer et al., 1995). Articulatory gestures are “units of action that can be identified by observing the coordinated movements of vocal tract articulators” and are the discrete actions that comprise phonological units (Browman & Goldstein, 1989).

Some researchers find that gesture is a natural unit of measurement both because of its task-oriented movement of the articulators and because it emerges as “prelinguistic discrete units of action in infants” (Browman & Goldstein, 1989, p. 98). Gestures are spatiotemporal in nature and have internal duration (Browman &

Goldstein, 1989), which reflects the inclusion of articulatory slowness, a measure of time, and abnormal scaling of articulatory gestures, a spatiotemporal measurement in Wiesmer et al.'s proposed definition of CAS (1995).

Non-speech characteristics of sCAS attributable to motor planning or programming deficits may include difficulty in performing volitional oral movements of the articulators, need for additional demonstration to perform sequenced volitional oral movements, poor auditory perception and auditory sequencing in comparison to children with normal speech but which is commensurate with non-dyspraxic children with SSD (Yoss & Darley, 1974).

Researchers in the area of sCAS have defined three segmental and suprasegmental features that are consistent with speech sound disorders at the planning or programming level:

- (a) inconsistent errors on consonants and vowels in repeated productions of syllables or words, (b) lengthened and disrupted co-articulatory transitions between sounds and syllables, and (c) inappropriate prosody, especially in the realization of lexical or phrasal stress (ASHA, 2007¹).

The position of ASHA is that the presence of these characteristics is neither sufficient nor necessary to the diagnosis of sCAS (ASHA, 2007¹). Indeed, this review of the literature found that there has not yet been a set of clinical indicators identified that separate the diagnosis of sCAS from speech sound disorders of other origins such as phonological disorders or dysarthria, a neurological motor speech disorder.

Phonological system. The articulation section demonstrated that aspects of sCAS do interfere with motor production and speech perception. This section will consider definitions of sCAS relating to the phonological system and in so doing will reveal that according to the present literature, communication difficulties encountered in sCAS also stem from faulty phonological representations.

The phonological system refers to the set of rules that govern how speech sounds relate to each other (ASHA, 2007⁴). The following quote illustrates the relationship of phonological disorders to speech sound disorders.

Speech sound disorders that impact the way speech sounds (phonemes) function within a language are traditionally referred to as phonological disorders; they result from impairments in the phonological representation of speech sounds and speech segments—the system that generates and uses phonemes and phoneme rules and patterns within the context of spoken language. The process of perceiving and manipulating speech sounds is essential for developing these phonological representations. (ASHA, 2007⁴).

Phonological representations are the mental representations of the sounds and sound combinations stored in memory that comprise the spoken words used to represent ideas or concepts (Claessen & Leitao, 2012).

Several assumptions are made in the literature about phonological representations: At birth the infant brain can discriminate among sounds belonging to all of the languages of the world. This phonetic sensitivity changes to become specific to the language(s) the child is exposed to as the child ages (Simon, Sjerps & Fikkert,

2013). This suggests that children, as opposed to adults with fully developed language grammars, are more sensitive to acquiring new phonological categories. Phonological representations, necessary to distinguish between lexical items that sound similar—e.g., mat, gnat—and to retrieve words are thought to become more specific as vocabulary develops (Claessen & Leitao, 2012). At the lexical level linguists consider the word to be the meaningful unit of analysis and acquisition (Pinnow & Connine, 2014). In the process of acquiring new words, the brain must form, store and retrieve a new phonological representation, a separate semantic representation and form neural links between the two (Claessen & Leitao, 2012). The mental lexicon is a part of declarative memory and contains all information necessary for speech recognition. The phonological representation in the mental lexicon is the underlying representation of an idea (Eulitz & Lahiri, 2004). Accordingly, impoverished phonological representations will be indicated in speech impairment as a correct representation forms the basis for a correct production. The phonological representation theory of childhood apraxia of speech

postulates that a core deficit in phonological planning impacts higher levels of the speech chain, thus parsimoniously accounting for the broad linguistic symptoms in the disorder. (Shriberg et al., 1997 p. 731 in Moriarty and Gillon, 2006).

Distinctive features theory. An aspect of phonological theory that contributes significantly to interventions in sCAS and therefore must be defined in this cognitive psychology section is distinctive feature theory. Jakobson noted that distinctive

features are thought of as "a set of... concurrent sound properties which . . . distinguish words of unlike meaning" (as cited in Blache & Parsons, 1980, p. 231). For example, the feature (+/- voicing) changes the meaning of the ideas /pɪg/ and /bɪg /.

Chomsky & Halle (1968) define distinctive features as components of language-independent phones with a limited set of permissible features and specify that phonological rules are based on the variance seen between underlying forms and phonetic output in speech (Parker, 1976). Most intervention literature in sCAS, however, takes its definition of distinctive features from Jakobson et al. (1952) who define distinctive features in terms of phonemic theory, the assumption that "...each phoneme is composed of a set of well defined distinctive features that are always present in the physical speech signal" (Parker, 1976, p. 27). The Jakobsonian system of distinctive features is given in *Fundamentals of Language* (Jakobson & Halle, 1971).

According to a study by LaRiviere, Winitz, Reed, & Herriman (1974), a categorization experiment attempting to assess the conceptual reality of distinctive features asked subjects to separate a series of sounds into two categories using either feature distinction alone or feature distinction and paired-associate memory. Immediate feedback was given so that the subjects could ascertain the categories. Data was presented for the following features: \pm vocalic, \pm voice, \pm nasal, \pm continuant and \pm strident. It was found that the features \pm continuant and \pm voice have no conceptual reality while nasal, strident and vocalic features do have conceptual reality. The authors posited that categorization of distinctive features reflects the effect of language

experience (La Riviere et al, 1974). This is consistent with the phonetic sensitivity changes seen in infants exposed to different languages cited by Simon, Sjerps & Fikkert (2013) because language experience shapes the brain.

Summary. This review reveals that communication difficulties encountered in sCAS stem from errors of perception, phonological representation and motor production, each of the three categories of speech sound disorders. Both theories of articulation and theories of phonological disorder contribute to the literature in sCAS. The articulation theories of sCAS, especially as demonstrated in non-speech movement disorders (Yoss & Darley, 1974) suggest a purely motoric etiology. Literature in the area of phonology suggests the motor difficulties seen in sCAS at the planning or programming level stem from a faulty phonological representation. The distinctive features theory analyzes speech production at the level of the meaningful feature and contributes some literature suggesting that certain features have conceptual validity while others do not, related to individual language experience.

There is currently no agreed upon set of diagnostic criteria for the identification of sCAS. The definition given in the position statement by the American Speech Language Hearing Association on Childhood Apraxia of Speech is

“Childhood apraxia of speech (CAS) is a neurological childhood (pediatric) speech sound disorder in which the precision and consistency of movements underlying speech are impaired in the absence of neuromuscular deficits (e.g., abnormal reflexes, abnormal tone). CAS may occur as a result of known neurological impairment, in association with complex neurobehavioral

disorders of known or unknown origin, or as an idiopathic neurogenic speech sound disorder. The core impairment in planning and/or programming spatiotemporal parameters of movement sequences results in errors in speech sound production and prosody” (ASHA, 2007¹).

While definitions of sCAS vary, according to Lewis and colleagues “The most commonly reported characteristics are difficulties sequencing phonemes and syllables, trial and error groping behaviors, and inconsistency in articulation with unusual error forms on both consonants and vowels” (Lewis et al., 2004, p. 159) which is consistent with the diagnostic criterion set forth by ASHA and other researchers (ASHA, 2007¹; Weismer, et al.; Yoss & Darley, 1974).

The brain structures involved in motor planning and programming, reception and representation of the speech signal will be discussed in the following section.

Contributions in Neuroscience to Definitions in sCAS

This section will discuss the contributions from the field of neuroscience to the understanding of sCAS. Neurological structures that have been identified as underlying core deficits in sCAS will be presented first followed by findings related to the central nervous system and peripheral nervous system.

Neurological structures. Information enters the brain through the body’s receptor organs and travels as neural signals up the spinal cord and into the brain stem where each input is processed and either passed higher up into the brain or discarded (Baars & Gage, 2010). The sensory organs and the types of input that they accept are as follows: the skin registers pressure, the nose registers scent, the tongue registers

taste, the eyes register light and movement and the ears register the properties of the sound wave (Baars & Gage, 2010). Considering the eyes and ears more specifically, a light source such as the sun or a lantern heats the surrounding air, causing it to spin off photons which reflect off of the surfaces of objects, creating a point of light that the eye registers. Because the eye can move and the neck allows the head to move, the eye can pick up multiple points of light, which are processed in order to see the edges of objects (Arwood, 2011; Baars & Gage, 2010).

When light photons reflect off the edge of an object the photoreceptor signal is picked up by intermediary neurons and then passed on to ganglion cells whose cell bodies reside in the retina of the eye and whose axons extend out of the retina to form the optic nerve. The ganglion cells receive excitatory input from a collection of rods and cones as well as excitatory and inhibitory input from bipolar neurons. The portion of the visual field that can be activated or strongly inhibited by that cell is known as the receptive field. Ganglion cells have center-surround receptive fields which means that they will not respond to uniform illumination where the strength of excitatory and inhibitory inputs is balanced. Rather they respond in a way that creates lateral inhibition. In lateral inhibition, the activity of a neuron may be inhibited by inputs coming from neurons that respond to neighboring regions of the visual field. Lateral inhibition enhances the neural representation of edges, regions of an image where the light intensity changes sharply and indicates contours, features, shapes or objects (Baars & Gage, 2010). Movement of the eyes within the head and movement of the head on the neck allow the eyes to take in multiple points of light which can be

processed by the brain to represent the edges of shapes (Arwood, 2007).

The visual field, the area in space perceived when the eyes are in a fixed, static position, can be divided into four quadrants. A horizontal line drawn from zero to 180 degrees through the center of the field defines the superior and inferior hemifields while a horizontal line drawn from 90 to 270 degrees defines the left and right hemifields. The four quadrants are called the superior and inferior nasal quadrants and the superior and inferior temporal quadrants (Tsuchitani, 1997). If the quadrants were drawn on a white board, the horizontal line would be drawn at eye level and the vertical line would be drawn down the mid-plane of the body; the outer edges of the quadrants would correspond to the temporal spatial limits of the outside edges of the body (E. Arwood, personal communication, January 21, 2012).

The ears accept the properties of the acoustic wave which are duration, amplitude and frequency (Arwood, 2011; Baars & Gage, 2010). It is the information brought to the brain through the spinal cord from the sensory receptors of the ear and eye that comprise meaningful patterns for language acquisition (Arwood, 2011).

Neuroscience literature contributes some assumptions regarding the representation of speech sounds in the brain. Given that speech perception involves the awareness of both the acoustic wave and the light wave, it is sometimes referred to in the literature as audiovisual speech (Stevenson et al., 2011). Temporal synchrony, the perception of simultaneity of discrete inputs, is the mechanism that allows sensory signals from a single event to be fused, or processed simultaneously in the temporal lobe and integrated; it also allows signals from differing events to be distinguished

from one another. The superior temporal cortex (STC)—a complex of brain regions—is a major site in the temporal lobe for integration of multisensory inputs including integration of acoustic and visual information. There are two mechanisms at play when audiovisual speech is integrated in the STC:

Integration of speech signals involves at least two processing mechanisms, one that reflects the physical temporal alignment of auditory and visual inputs, and another that reflects the psychological phenomenon of perceptual fusion of separate channels into a coherent perceptual gestalt. (Stevenson, et al., 2011, p. 7)

Patients with Autism Spectrum Disorder, schizophrenia and dyslexia have been shown to demonstrate functional and structural differences in the STC, including impairment in temporal processing of audiovisual speech as well as impairments in perceptual fusion as evidenced by decreased susceptibility to the McGurk effect, an illusion which occurs when the acoustic component of one sound is paired with the visual component of another sound to create the perception of a third sound (Stevenson, et al., 2011). It is evident through these clinical populations that not all brains demonstrate temporal synchrony. In other words, not all brains demonstrate the capacity to integrate acoustic and visual information to form auditory perceptions or representations. This is supported by findings from Yoss and Darley (1974) wherein the authors found that children with speech sound disorders (SSD) had poorer auditory perception and auditory sequencing ability compared to age and gender matched controls. Additionally the SSD group had similar within-group performances on

auditory tasks, indicating a common deficit in the auditory perceptual domain and suggesting a common problem in integrating acoustic and visual inputs (Yoss & Darley, 1974).

A closer look at the regions of the superior temporal cortex reveals that speech may be processed hierarchically in auditory pathways. Specifically, the dorsal superior temporal gyrus (STG) is responsible for initial acoustic analysis while the ventral superior temporal sulcus (STS) and middle temporal gyrus (MTG) are responsible for phonological processing. Processing of high-level information in ventral brain regions modulates activation elicited by low-level information in dorsal brain regions; dynamic interactions between core auditory and downstream regions involved with acoustic and phonological processing are at the crux of speech perception (Zhang et al., 2011).

Given that patterns of neural activation for integration of temporal auditory inputs have been imaged, it should also be possible to image brain areas implicated in the formation of faulty phonological representations. According to Arsenault and Buchsbaum, perceptual confusability—the behavioral tendency to confuse one phoneme with another—should be evident as patterns of neural similarity in brain structures critical for acoustic-phonetic perception (2015). In a listening task devoid of visual speech cues 24 participants heard a consonant-vowel syllable stimulus while lying in an MRI scanner and attending visually to a plus sign. The participants could not see the speaker's face nor any movement of the articulators as the stimulus was provided through an audio recording. Blood oxygen level dependent (BOLD) activity

demonstrated that neural activity associated with patterns of phonemic confusability occurred bilaterally in the auditory cortices. There was no BOLD activity captured in the frontal-motor cortices (Arsenault & Buchsbaum, 2015). Significantly, phonemic confusion occurs in the absence of motor cortex involvement. Evidence for clarity of speech perception and production based on intentional recruitment of the motor cortex will be discussed in the intervention section.

Central nervous system. The central nervous system (CNS) encompasses the brain, spinal cord and cranial nerves that connect the CNS to the peripheral nervous system. One important finding in defining what sCAS is and is not, is the identification of a genetic component expressed in the brain. The three generational KE family has been reported on extensively in the research literature as half of the family members present with Childhood Apraxia of Speech (Lai et al., 2001; Lai et al., 2003; Lewis et al., 2004). Members of the KE family who present with sCAS have been found to experience onset of orofacial dyspraxia, reduced ability to voluntarily control movements of the lips, tongue and soft palate, in early childhood followed by later impairments in the development of linguistic and grammatical skills (Lai et al., 2003; Lewis et al., 2004). Each family member who presents with the sCAS phenotype also has a unique gene mutation located at chromosome 7q31 called the FOXP2 gene, which is a transcription factor gene expressed in the brain (Lewis et al., 2004). Neuroimaging studies on the family have found abnormalities in the frontal lobe and associated motor systems (Lewis et al., 2004) and specifically have found reduced volume bilaterally in the superior portion of the caudate nucleus, one of the

structures of the basal ganglia in the cerebrum of the brain, as well as bilateral functional differences in the caudate nucleus of the basal ganglia (Lai et al., 2003; Lewis et al., 2004). Rodent studies on FOXP2 expression, during brain development, indicate that the FOXP2 gene is found in motor related circuits including the basal ganglia, thalamus, inferior olives and cerebellum (Lai et al., 2003). In their discussion of the impact of the FOXP2 gene mutation on the central nervous system development in rodents and humans, which they assert to be similar, Lewis and colleagues submit that the FOXP2 gene may account for the oro-motor problems seen in people with sCAS and the linguistic and grammatical impairments may be secondary consequences of deficits in motor planning and sequencing or the motor and cognitive problems could arise simultaneously (2003).

Peripheral nervous system. The peripheral nervous system consists of the nerves and ganglia outside of the brain and spinal cord. The peripheral nervous system is indicated in non-speech movements that characterize sCAS. In an historical article by Yoss and Darley the authors found that children with speech sound disorders (SSD) had increased difficulty with both isolated and volitional oral movement compared to age and gender matched controls (1974). There were within-group differences on isolated and volitional oral movement tasks, which were highly correlated with neurological findings.

“Most frequently noted on the pediatric neurologic examination were alternate motion rates of the tongue and extremities and difficulties in gait and coordination” (Yoss & Darley, 1974, p. 407). Significantly, although motor impairment in oral movement

was correlated to neurologic findings across effector systems, it was not a consistent diagnostic marker in children affected with sCAS as in adults. The authors noted that

The trial-and-error movements and audible gropings for successful placement of the articulators that often are prominent in adults with acquired apraxia of speech were, for the most part, absent in the [children with CAS]. Only a few of these children, usually the oldest ones, evidenced this behavior and did so most noticeably in the production of three-syllable words. Retrial and self-correction also were not typically found... supporting the observation by Morley (1965) that children with a developmental apraxia of speech are usually unaware of their errors, whereas adults with apraxia of speech typically recognize their errors and attempt to correct them. (Yoss & Darley, 1974, p. 411).

Summary. Neuroscience evidence shows that people with speech sound disorders experience a lack of temporal synchrony in the auditory cortex of the brain because visual and acoustic inputs are not able to be processed simultaneously. Phonemic confusability may also result in lack of accurate phonological representations. Mutation of the FOXP2 gene has been shown to coincide with structural and functional deficits in the areas of the brain where it is expressed and may be responsible for the oral motor difficulties found in members of the KE family with sCAS. Difficulty with isolated and volitional oral movements as well as gait and motor coordination are common among populations with sCAS although a difference is seen in adults' attempts to correct erroneous productions versus children's seeming

unawareness of errors. While AOS is characterized by disruption in the motor planning system to produce speech and may be remediated at that level, sCAS must be considered within the parameters of the developing language system. The poor auditory perception and auditory sequencing seen in both children with sCAS and children with SSD may point to a common etiology in the language system. All sensory inputs are integrated in the temporal lobe (Baars & Gage, 2010). However research has repeatedly documented temporal auditory processing disorders in children with speech sound related disorders including sCAS (Kent, 2000; Shriberg et al., 1997; Yoss & Darley, 1974). Auditory input is comprised of the semantic features of the visual system (light, movement) integrated with the semantic features of the acoustic sound wave (duration, frequency, amplitude) (Arwood, 2011; Baars & Gage, 2010). Research has shown that the ability to combine multiple inputs such as the integration of acoustic and visual information into a single percept is key to the ability to interact with the world (Stevenson et al., 2011). It is also the basis for auditory thinking, thinking that is based on sound (Arwood, 2011). A failure to integrate the acoustic and visual inputs in the temporal lobe results in not only temporal asynchrony (Stevenson et al., 2011) but also a cognition that is not auditory and by default must be visual (Arwood, 2011). Therefore temporal auditory processing disorders imply visual cognition, a way of learning to think and acquire language, an idea that will be explored in more detail later in this review. Language acquisition in visually impaired populations with visual cognition will also be addressed.

Contributions in Language to Definitions in sCAS

The previous two sections addressed literature that contributes to definitions of sCAS from the fields of cognitive psychology and neuroscience. This section presents a review of language literature that contributes to definitions of sCAS. In the dominant lens, language is considered using the word as the unit of analysis (Arwood, 2011). The structures of language, which are measurable, are categorized as phonology, morphosyntax and semantics. This section will be organized according to those categories.

According to ASHA, language is “a complex and dynamic system of conventional symbols that is used in various modes for thought and communication.”

and

“Contemporary views of human language hold that:

1. Language evolves within specific historical, social, and cultural contexts;
2. Language, as rule-governed behavior, is described by at least five parameters
phonologic, morphologic, syntactic, semantic, and pragmatic;
3. Language learning and use are determined by the interaction of biological, cognitive, psychosocial, and environmental factors; effective use of language for communication requires a broad understanding of human interaction including such associated factors as nonverbal cues, motivation, and sociocultural roles” (ASHA, 1982, para 3).

Most of the literature to this point has dealt with sCAS as a speech disorder. A speech disorder occurs when a person has difficulty producing sounds in syllables and

words and results in an impairment of the articulation of speech sounds, fluency or voice (ASHA, 1993). This is different from a language disorder which is defined as impaired comprehension or use of spoken, written or other symbolized language systems (ASHA, 1993). According to the American Speech Language Hearing Association,

Language is different from speech. Language is made up of socially shared rules that include the following:

1. What words mean
2. How to make new words
3. How to put words together
4. What word combinations are best in what situations. (ASHA, 2007⁵).

A language disorder is defined as impaired comprehension or use of spoken, written or other symbolized language systems. It can include form, content or function of language. Specifically, form of language can be impaired in the areas of phonology, morphology or syntax with phonology being defined as “the sound system of a language and the rules that govern the sound combinations” (ASHA, 1993, para. 3). In this sense, sCAS falls under both the categories of a speech disorder in that speech sounds are produced atypically in a manner that interferes with intelligibility and a language disorder in that intervention in sCAS, as will be seen in the treatment section below, is often approached through the phonological system.

The phonological system. Some researchers have demonstrated that a phonological deficit, rather than cognitive or linguistic impairment, is at the heart of

language learning impairments (Tallal, et al., 1996). These researchers found that children with language learning impairments experience difficulty processing the rapidly changing sensory inputs that make up the acoustic waveform. Specifically, phonemic contrasts such as the difference between /pɪg/ and /bɪg/ are signaled in tens of milliseconds. Tallal et al. (1996) found that language learning impaired children can identify syllables “when rates of change of critical formant transitions are simply synthetically extended in time by about twofold” (p. 81). This change is referred to as temporal modification of the acoustic wave, an intervention which will be discussed further in the treatment section of this review.

Despite the omission of a reference to the underlying language system on which oro-motor speech is based in the ASHA definition of sCAS, some researchers assert that children with sCAS have concomitant language disorders owing to an impaired phonological representation system (Kent, 2000; Shriberg et al., 1997). In one model asserted by Shriberg et al. (1997) the breakdown in the system occurs as an impairment in the temporal auditory processing of the stimulus at the input level. In other words, children with sCAS do not make correct phonological representations of auditory input (Shriberg et al., 1997). This implies that sCAS would qualify as a language-based disorder as phonology is in ASHA’s definition a component of the form of language. It also implies that language is involved since auditory processing in the brain is involved in language.

Morphosyntax. Morphology, the study of word structure, and syntax, the study of sentence structure, can be referred to together as morphosyntax.

Morphosyntax is related to phonology as both are components of language forms or structures. At this junction it is appropriate to define the difference between surface structures and deep structures. Surface structures are products of the thinking and language system and in English refer to "...words, phrases, sentences, parts of speech, syntax, phons, morphemes and so forth" (Arwood, 2011, p. 386). Deep structure on the other hand refers to language function, the underlying processes that support the surface structures (Arwood, 2011). Examples include the purpose or intention behind a communication act. Searle supports the idea that deep and surface structures are separate, stating,

"The unit of linguistic communication is not, as has generally been supposed, the symbol, word or sentence, or even the token of the symbol, word or sentence, but rather the production or issuance of the symbol or word or sentence in the performance of the speech act" (Searle, 1969, p. 16).

The deep structure supports the surface structure and the surface structure represents the underlying deep structure.

Research has shown that children who experience speech delays also demonstrate delays in syntax (Paul & Shriberg, 1982). Increases in length and complexity of linguistic strings in sentence repetition tasks are associated with increased phonological production errors. The theoretical explanation for this phenomenon is that language is organized hierarchically in the brain in terms of syntactic, morphological and phonological elements and speech-delayed children have a limited capacity to manage hierarchical complexity during encoding, resulting in

loss of phonetic accuracy because of competing demands for processing resources at higher linguistic levels (Paul & Shriberg, 1982).

Concurrent with ASHA's definition of the forms of language, research literature continues to, for the most part, address language as if it can be separated into its component parts and manipulated. Sentence production, for instance, is frequently treated as having a top-down hierarchical organization for processing where syntactic structures organize and control phonological structures so that the demands of processing syntactical information can disrupt phonological processing (Panagos & Prelock, 1982). In one such article examining the effect of a top-down processing model, treatment was manipulated for twenty-seven preschoolers with delays in both morphosyntax and phonology. Twenty of the children received treatment while the other seven, due to scheduling delays or the parents' choice of a wait-and-see approach, did not receive treatment during the study period and were used as a control group. Treatment was manipulated to address either the child's phonological disorder or the child's morphosyntactic disorder in order to examine cross-treatment effects. In a top-down processing model, the implication is that organizational changes at higher linguistic levels of processing will affect changes in lower levels, assuming that morphosyntax represents a higher level of processing than does phonology although both are surface structures. The study revealed a cross-domain effect for morphosyntax intervention but no cross-domain effect for phonology intervention. Specifically, children who had the morphosyntax intervention exhibited a statistically significant change in phonology with a large effect size. The children who received

phonological intervention did not exhibit statistically significant changes in morphosyntax. This result was found regardless of which treatment the child had first, as all children ultimately received both treatments (Tyler, Lewis, Haskill & Tolbert, 2002). In the morphosyntax treatment, which yielded speech-induced changes in corticospinal excitability, manipulation of word endings such as plurals and tense markers addressed both the change in meaning at the morpheme level and the phonemic change that separates each morpheme. By contrast, the phonological intervention dealt only with the sound system, manipulating the individual phonemes outside of the context of language. It may be considered that morphosyntax necessitates a higher level of processing than phonology which supports the notion that there is a connection between the semantic deep structure required for syntax and the phonological surface structure required for speech.

Other authors have also considered the relationship between morphosyntax and phonology. Panagos suggested, in 1979, that children who demonstrate phonological simplifications will do so more as grammatical complexity increases because they have an overall deficit in hierarchical organization of syntactic, morphological and phonological elements (Paul & Shriberg, 1982). Paul and Shriberg suggest four potential patterns of association between phonology and syntax in speech-delayed children whom they define as those children whose phonological errors in stage III, deletions and substitutions, persist beyond the typical age of suppression. First, a limitation in encoding capacity could account for an overall syntactic delay with an even greater deficit in producing phonetically complex morphophonemes—those

morphophonemes that require the addition of a consonant rather than a vowel or consonant(s) change or the addition of another syllable (e.g., plural, possessive, regular past tense, regular third person singular). On the other hand, the limitation in encoding capacity could account for children whose general level of syntactic production is age-appropriate, but who show deficits in correct production of complex morphophonemes, at and below, their age-appropriate syntactic level. This notion is based on an assumption that syntax is a surface structure acquired as a product of unfolding development rather than as a representation of underlying concepts. The third relationship proposed is a delay in general syntactic skills with no additional limitation on the production of phonologically complex morphophonemes and the fourth and final relationship is exhibited in age-appropriate production of all syntactic and morphological structures resulting in no interaction between productive phonology and syntax, actually a non-relationship.

Semantics. Semantics refers to an area of language that studies how meaning is acquired. Data from functional neuroimaging show that inferior and lateral regions in the temporal lobe can be differentially activated by different categories of objects (Caramazza & Mahon, 2003). Assuming that the temporal lobe regions correspond to storage of visual semantic information, researchers reason that this is evidence for two independent levels of concept organization, domain-specific and modality-specific. Neuroimaging supports the idea that different areas of the brain are differentially involved in processing and storing information that corresponds to different categories of objects, but the data could be reflective of modality specific input rather than

category specific (Caramazza & Mahon, 2003). These findings support the domain specific hypothesis, that is to say, semantic features of concepts are stored in the area of the brain corresponding to the sensory organ that receives the information. The domain specific hypothesis, then, will result in the creation of widespread neural circuits and networks for concepts as distal portions of the brain are activated for unique representations.

This view is supported by the semantic representation theory, which postulates that the same neural systems used in perception and action are recruited for processing and storing semantic information (Vigliocco, Lotte, Andrews & Kousta, 2009). The semantic representation theory takes an embodied view of cognition, which is consistent with literature describing cognition as being grounded in bodily states, modal simulations and situation action. The three tenets of this theory are: (1) semantic knowledge is represented across all domains of knowledge; (2) experiential learning includes affective/emotional information (especially for abstract learning); (3) language also provides information for semantic representation (e.g., abstract concepts cannot be learned on the basis of sensorimotor input alone) (Vigliocco et al., 2009).

While this theory does not fully support the domain specific hypothesis, it extends to suppose that the two modes of learning abstract concepts are experiential, comprised of the sensorimotor and affective systems, and language derived. The theory does not allow for language to name emotional concepts, assuming rather that emotional development precedes linguistic development.

“Semantics is not only embodied in externally derived sensory-motor

representations. We also argue that once we move from concrete to more abstract domains of knowledge, language processing automatically and immediately engages the system that processes emotions. After word learning has first been grounded in experiential information, linguistic information can and does provide another extremely rich source of data from which meaning can be learnt” (Vigliocco et al., 2009 p. 242).

Other authors would disagree with the tenet that emotional development precedes linguistic development on the basis that all development is learned and the naming of emotions requires a formal level of conceptual language (Arwood, 2011). Nonetheless, the semantic representation theory helps to explain that all information is acquired through the sensory motor system in terms of perceptual patterns, which are overlapped to form concepts, and named by language (Arwood, 2011, Baars & Gage, 2010; Vigliocco et al., 2009). In this way abstract learning is furthered as language is used to assign meaning to the perceptual patterns that are acquired through the sensory-motor system.

The limited capacity theory of language proposes that word learning, which continues into adulthood, requires the function of at least three systems: semantics, phonology and working memory. In this framework, word learning is a task with high cognitive processing demands because it requires that several components—namely the phonological representation of a word and the semantic features of the idea to which the word refers—be encoded simultaneously. Deficits in word learning are explained as a function of limited capacity for processing.

“There is a finite pool of processing resources available for cognitive tasks.

As any aspect of a task becomes more difficult, demand on processing resources increases and task performance may suffer globally” (Alt & Guzman, 2009, p. 3).

In a study of adults with normal language, and adults with a history of disorders of spoken and/or written language with or without concomitant Attention Deficit Hyperactivity Disorder (ADHD), all groups showed a pattern of accuracy for recognizing semantic features, the existence or non-existence of pre-defined categories. Specifically, the presence or absence of eyes (animacy) was the most accurate feature, followed by color, shape, and then pattern (Alt & Guzman, 2009). One possible explanation is found in global versus local features. From an evolutionary perspective, the presence or absence of animacy would be an indicator of whether an object might be a predator, a semantic recognition linked to survival. Another explanation might be the idea of whole to parts where a gestalt requires less processing resources than the individual pieces. Literature presented in the language theorists section of this review will show that the processing limitations imposed by the limited capacity theory may be mitigated through chunking of semantic information. This is important to this study because semantic interventions may demonstrate an advantage over phonological or sound based interventions in the ability to consider a great deal of information simultaneously through chunking. Chunking refers to grouping perceptual stimuli into larger conceptual groups such as letters into words (Gobet, Lane, Croker, Cheng, Jones, Oliver, & Pine, 2001).

Summary. The phonological, syntactic, morphological and semantic components of language are interrelated. Language form can be impaired due to a deficit in any of these systems and can occur concomitantly in populations with sCAS. Children with language learning impairments have difficulty processing the rapidly changing sensory inputs of the acoustic wave. The impairment appears to occur in processing the auditory—simultaneous acoustic and visual—stimulus at the input level, yielding a faulty phonological representation which will lead to phonological production errors at the surface structure level. A positive association exists between linguistic complexity and phonological production errors which is theorized by some to result from limited encoding capacity. The limited encoding capacity suggests that the semantic features of a concept and its phonological representation are encoded simultaneously and when the task increases in complexity it requires more processing resources which could cause task performance to suffer globally, accounting for the programming/planning and execution errors seen in sCAS. Chunking semantic information by working on deep structures, or the functions of language, as an alternative to dual encoding of phonological representations and semantic features of a concept may offer a way to circumvent the performance errors seen in sCAS.

Summary of Definitions in Childhood Apraxia of Speech

Suspected Childhood Apraxia of Speech (sCAS) remains a nebulous diagnosis in the communication sciences and disorders due to the lack of agreement in the research literature regarding diagnostic criteria that separate sCAS from other speech sound, motoric or language-based disorders such as articulation disorders, dysarthrias

and phonological disorders respectively. This literature review is organized according to the three-prong approach to neuroeducation. From the cognitive psychology lens, sCAS is viewed in terms of speech products and theories of the mind are drawn from the difference in the verbal speech that children with sCAS produce compared to typically developing children and adults. Through the lens of cognitive psychology, the variations in production including errors and distortions in articulation, prosody, voicing, and non-verbal oro-motor movement are theorized to stem from disorders of phonological representations in the mind which impact higher levels of the speech chain. In this literature, production errors in sCAS are thought to stem from underlying difficulties in the perception and manipulation of speech sounds (ASHA, 2007⁴).

Neuroscience literature contributes an understanding of the functional and structural differences that occur in the brain and nervous systems of people with sCAS compared to typically developing populations. Clinical populations, such as those with autism, schizophrenia, and dyslexia, demonstrate a lack of temporal synchrony in the auditory pathways based on neuroimaging. A lack of temporal synchrony can result in auditory processing disorders. Significantly, research published by Yoss & Darley in 1974, before the advent of much of the modern technology that allows for high resolution spatial and temporal brain imaging, suggested that populations with speech sound disorders also experience poor auditory perception and auditory sequencing ability compared to typically developing peers. Neuroimaging demonstrates that phonemic confusion, which is evident in faulty phonological representations, occurs in

the auditory lobes bilaterally in the absence of motor cortex involvement. This literature adds dimension to the cognitive psychology literature as it supplies functional and structural explanations for the difficulty in perceiving and manipulating speech sounds, naming differences in the auditory lobes of the brain.

On the other hand, the neuroscience and cognitive psychology literature do not necessarily align in regard to processing paths. Whereas the phonological theory of sCAS suggests that lower level information affects higher level processing, neuroscience literature suggests that information is processed hierarchically in auditory pathways and that higher-level linguistic information will mediate lower-level information. The difference is a bottom up versus a top down processing approach. These differences can be attributed to integration and inhibition functioning simultaneously (Baars & Gage, 2010).

Some evidence for a genetic component to sCAS has been found in studies such as those of the KE family where the FOXP2 transcription gene has been traced and found to be evident in areas of the brain underlying motor control. Some researchers theorize that the frontal lobe and motor system abnormalities of individuals with the FOXP2 gene transcription may account for the oro-motor difficulties seen in this population.

The language lens contributes to the definition of sCAS primarily in terms of language structure; language function, the underlying thinking that language represents, is not discussed. The literature supports that impairment in processing sound occurs at the stimulus input level resulting in impaired language form in the

area of phonology. Children with phonological production errors also show difficulty as linguistic complexity rises and the limited encoding capacity is again brought into play to explain the production errors as resulting from complex demands on the linguistic processing system.

The following section will address the current practices in assessment and intervention in sCAS.

Assessment and Interventions in Childhood Apraxia of Speech

Owing to a lack of consensus in the research literature regarding behavioral characteristics that describe suspected Childhood Apraxia of Speech (sCAS), there is not a consistent means of assessing children with speech sound disorders for a differential diagnosis of sCAS. Each research study assesses subjects based on the researcher's working definition of sCAS. Therefore there is a lack of strong assessment data in the area of sCAS resulting from lack of consensus in the literature regarding diagnostic criteria. The remainder of this section will consist of a review of the literature surrounding interventions for sCAS. The literature will be divided into two sections according to the research literature dealing with sCAS as a speech sound disorder and as a language disorder respectively.

Speech sound disorder. An important point in the consideration of treatment methodologies for sCAS is that the language, phonological, and motor systems develop concurrently in children (Murray, McCabe & Ballard, 2014). Keeping this in mind, various treatments attempt to influence the speech sound production system through modifications or alternations on the action of the phonological, motor or

linguistic systems. According to the American Speech-Language Hearing Association (ASHA),

“Speech is the verbal means of communicating. Speech consists of the following:

Articulation: How speech sounds are made; Voice: use of the vocal folds and breathing to produce sound; Fluency: the rhythm of speech. When a person has trouble understanding others (receptive language) or sharing thoughts, ideas and feelings completely (expressive language), then he or she has a language disorder. When a person is unable to produce speech sounds correctly or fluently, or has problems with his or her voice, then he or she has a speech disorder” (ASHA, 2007⁵).

ASHA’s scope of practice for Speech Language Pathologists refers to speech sound production, language comprehension and expression and cognition as separate areas of practice (ASHA, 2007³). Therefore it is common for research in the area of sCAS to deal with the phonological system or other aspects of speech production such as resonance, voicing and motor planning separate from thought and language. The following sections will address contributions in the areas of cognitive psychology, neuroscience, and language to intervention in sCAS as a speech sound disorder.

Intervention: contributions in cognitive psychology. As a field that deals with how knowledge is organized in the mind, interventions stemming from the lens of cognitive psychology primarily deal with patterns of speech sounds such as those arising from the phonological system: phonological patterns. Treatment approaches

such as multiple oppositions, minimal pairs and a software program called Sound Contrasts In Phonology (SCIP), a computer-based intervention, all attempt to isolate and treat the components of the phonological system. Multiple oppositions is a treatment aimed at reducing homonymy in phonemes, a condition where the child uses one sound for many sounds represented in the adult sound system. In this protocol, up to four target sounds may be treated simultaneously (Williams, 2012). In a review of three studies incorporating these various approaches, Williams found that to affect a change in the phonological system as represented by an increase in percentage of correct underlying representations (PCUR), a dose of greater than 50 trials per session for a duration of at least 30 sessions is needed to affect a significant treatment gain. Changes in PCUR below this level of intensity demonstrated limited effectiveness. For severe cases of speech sound disorders, the recommended treatment intensity was at least 70 trials per session over a course of 40 sessions. The length of the session is a consequence of the time needed to affect the specified minimal number of trials, although over this period of time, other changes in the language processing system could not be ruled out as affecting outcomes. Williams reported a statistically significant effect in PCUR for a concentrated versus a dispersed intervention schedule with the former being defined as 3 sessions per week for 8 weeks and the latter 1 session per week for 24 weeks. Quantitative factors observed across studies denoted a twenty percent increase in productions during the first half of a session when a child was learning a new sound compared to the latter half of a treatment session. Qualitative observations included a roughly 2:1 ratio of sound productions in

structured practice versus naturalistic play. The average change in PCUR in the two studies that used multiple oppositions or multiple oppositions and minimal pairs was 25.5 while the average change in PCUR for the computer-based intervention was only 3 (Williams, 2012).

It is not insignificant that a great deal of time is necessary to affect a modest change in the sound production system using a phonological approach to remediation of speech sound disorders including sCAS. A five-year study in Madison, WI found that the highest referral reason from school-based Speech Language Pathologists (SLPs) to a university clinic for sCAS was due to lack of or slow progress using traditional treatment methods (Shriberg et al., 1997).

Another intervention that takes place over an extended time period but which is considered abbreviated compared to a sound-by-sound intervention targeting each error individually is the phonological cycles approach (Hodson, 2011). The Hodson cycles approach considers patterns of deviation from adult speech to be phonological processes. Children who are treated with the cycles approach receive intervention for at least one hour per week for 5-16 hours per phonological process. A cycle consists of treating all of the relevant phonological processes for the hours indicated. Hodson reports that most children become essentially intelligible in 3-4 treatment cycles. Treatment is focused on stimulating non-stimulable sounds—e.g. those that the child cannot produce correctly—and facilitating production of stimuable sounds with assistance in the form of amplification and tactile cues as needed, fading to independent production. Target syllables and words are chosen based on facilitative

phonetic environments with the goal of 100% accurate productions, reinforcing an accurate kinesthetic image of the target phoneme (Hodson, 2011). The Hodson approach also targets the phonological system.

Intervention: contributions in neuroscience. The neuroscience subsection of the definitions in sCAS section above demonstrated that the acoustic wave is processed in the auditory pathways of the temporal lobe but that due to a lack of temporal synchrony, not all brains are able to perceive the rapidly changing inputs of the acoustic wave or perceive the visual and acoustic properties of audiovisual speech as a single event (Stevenson, et al., 2011; Tallal et al., 1996). Interventions based on distinctive features, which were discussed in the diagnostic criterion section above, attempt to manipulate how the brain processes sound by focusing on the individual features in error across phoneme error patterns. “Distinctive features are the contrastive elements that compose the sound system of a language. They are the minimal phonetic elements that, when grouped together, comprise a phoneme” (Costello, 1975, p. 61).

Interventions have been formulated based on generative phonology and distinctive features on the premise that children’s articulation errors are not random but stem from a set of rules, different than the rules that govern adult speech, which are related to the concept of distinctive features and strategies for their acquisition (Costello, 1975). The distinctive features approach to speech sound disorder remediation posits that since a child’s articulation errors are rule-governed, the child can be taught the appropriate underlying rules and/or distinctive feature rules to affect

articulation change. Since each phoneme is a bundle of distinctive features, yet no phoneme has the exact same set of distinctive features as another; multiple phonemes can be affected by one feature error. Thus it is posited that if the child learns the rule to use a particular feature correctly, he should be able to correct all of the error phonemes that have the feature in common (Costello, 1975). Use of distinctive features is another intervention that focuses on the phonological system.

In a case study intervention two children age 4;5 and 4;2 with multiple articulation errors received 16 hours and 25 hours of treatment based on distinctive features theory respectively. The authors found that the treatment was effective for remediating deviant phonological systems through the level of spontaneous conversational speech as illustrated by the seven error phonemes that changed resultant from instruction on three treated phonemes (Costello & Onstine, 1976). The children's language levels before and after treatment was omitted from the study.

Intervention: contributions in language. As discussed in the morphosyntax section, the theory of hierarchical processing implies that treated aspects of language which are processed at higher linguistic levels in the brain can affect changes in language aspects processed at lower levels. Further evidence for support of top-down processing, which implicates neurological feedback from higher levels of processing areas in the brain to lower levels, is found in a study which showed that language intervention that focused on expanding vocabulary resulted in broadened phonological diversity. The principles of exclusivity and contrast dictate that a child will not apply two labels to one object (Alt, Plant & Creusere, 2004). Children who know many

words produce more sounds and sound combinations than children who know fewer words (Storkel & Morrisette, 2002). Combining the two principles, children will be restricted in their ability to apply lexical labels when their phonological system is impoverished as a result of an underdeveloped linguistic system. A two-representation model is a connectionist model which means that representations can be activated.

“Hearing or thinking about a word provides external activation to a lexical representation. *For a word to be recognized or produced, the activation of its representation must reach a set activation threshold*” (Storkel & Morrisette, 2002, p. 26, emphasis added).

The authors examined the link between lexical and phonological development by considering the acquisition process of language beyond the 50-word stage. In so doing they applied a cognitive model of spoken word perception and production. There is a known rapid increase in the rate of word learning after the 50-word threshold is crossed, and some researchers believe that there is a change in the word learning process at this point from a holistic process to an analytic process of the phonological system although it could also be a result of layers of semantic features overlapping. In the former vein, consideration is given to a word’s neighborhood density, which refers to a mental lexicon based on phonological similarity; a neighborhood for a particular word will include all words differing from the target word by one phoneme whether it is an addition, deletion or substitution. All neighbors of a word are considered equally related to the word and the number of neighbors determines the degree of activation damping for the target word. The denser the neighborhood, the more damping of the

target word, which means the more inhibition that will occur neurologically. A word from a dense neighborhood will be more impeded in reaching the activation threshold for recognition or production than a word from a sparse neighborhood. Studies of adults with intact language show increased accuracy in the recognition and production of words from sparse neighborhoods compared to those from dense neighborhoods (Storkel & Morrisette, 2002). Accordingly,

“two aspects of the phonological representation are affected by phonotactic probability—resting threshold and connection strength. . . .common sounds are more activated at rest than are rare sounds. Consequently, common sounds should reach the activation threshold for recognition or production more rapidly than should rare sounds. Once a lexical representation is activated, it will also activate its corresponding phonological representation. Activation can also occur in the opposite direction, with a phonological representation activating corresponding lexical representations. These connections between lexical and phonological representations allow for interactions between lexical and phonological processing” (Storkel & Morrisette, 2002, p. 28).

Significantly, although a two-way activation path is present, lexical processing dominates phonological processing in real words. This is not the case for non-words, which do not have a lexical representation (Storkel & Morrisette, 2002). That lexical processing takes precedence over phonological processing when competing demands exist both makes reading with phonemes (e.g., sounding out words) a difficult task for

children with impairments in temporal auditory processing and indicates that use of context will be a strength for the same population in reading and in speaking tasks.

Neighborhood density, a lexical variable, would predict that the word “sit” which is from a dense neighborhood would be inhibited relative to a word from a sparse neighborhood. But phonotactic probability, a phonological variable, would predict that “sit,” with its common sound sequence, would be facilitated relative to a word having a rare sound sequence. This is borne out in adult studies—recognition of real words from dense neighborhoods is inhibited relative to real words from sparse neighborhoods. This does not apply to children with specific language impairment (SLI) who have been shown to not demonstrate a learning advantage for common over rare sound sequences.

“When children were taught sounds in frequently occurring words, they made significant gains in their production accuracy of the target sound. In contrast, when children were taught sounds in words from dense neighborhoods, they failed to learn the treated sound. This suggests that phonological treatment should focus on frequent words in the language and avoid the use of words from dense neighborhoods. Based on the Gierut et al. (1999) study, treatment in words from dense neighborhoods resulted in minimal or no learning of the treated sound” (Storkel & Morrisette, 2002, p. 32).

The implication is that in working on phonology out of context, one will encounter a great deal of similarity of sound which will be difficult for those children with deficits in auditory processing. Intervening to expand vocabulary in order to broaden

phonological diversity is a means of intervention based on consideration of the linguistic system to affect the phonological system. Interventions based on consideration of neighborhood density and phonotactic probability are aimed at remediation of the phonological system.

Based on the phonological representation theory of childhood apraxia of speech, it can be assumed that children with poor phonological representations will have difficulty with reading when the reading task is undertaken using a phoneme to grapheme correspondence approach. In a study of three students with sCAS who received seven hours of phonological intervention in the area of phoneme-grapheme correspondence over a period of three weeks, two students showed an improvement in their speech production and one, a student with a nonverbal intelligence score of 69 who spoke in single word utterances, did not (Moriarty & Gillon, 2006). Considering the student who did not make progress with the phonological intervention approach, it might be postulated that the student did not possess the underlying language foundation, a full adult grammar, necessary to manipulate the individual products or sounds that come out of the language system. This conclusion can be drawn from the assumption that a positive correlation exists between language and cognitive ability as measured on a standardized test of intelligence (Sandel, 1998).

Summary. As a speech-sound disorder, intervention in sCAS focuses on isolating and treating the patterns that are thought to be a product of the phonological system through such varied treatment methodologies as SCIP, Hodson Phonological Cycles, Minimal Pairs and others. Manipulation of distinctive features attempts to

change how the brain processes the acoustic wave by targeting for remediation those features which are in error across patterns of phoneme production. Language approaches to sCAS as a speech sound disorder draw on theories of lexical processing in which the word is the meaningful unit of analysis and acquisition (Pinnow & Connine, 2014) and attempt to isolate treatment targets through consideration of neighborhood density of words and phonotactic probability which yield similarity of sound. Most approaches are primarily aimed at remediation of the phonological system.

Language disorder. In the first section of this literature review it was established that sCAS is both a speech sound disorder as it manifests in errors of articulation in the production of verbal speech and a language disorder as it results from ineffectual processing at the input level of the acoustic wave, leading to inaccurate phonological representations. This section will review the treatment literature that considers sCAS as a language-based disorder through the cognitive psychology, neuroscience, and language lenses.

Although not all studies show phonology as the gateway to the acquisition of language, one approach to language is to see it as a disruption in the phonological system. Most language literature approaches language acquisition from a surface structure standpoint. Those studies that do deal with semanticity neglect to consider how semantic features are acquired through the sensory receptors. While studies show that the brain can be trained to recognize the properties of the acoustic waveform, semantic meaning is missing (Merzenich et al., 1996; Tallal et al., 1996). Although

much of the sCAS literature supposes that the impairment is specific to programming or planning speech, it appears that the deficit may occur earlier, in the temporal auditory processing of the sound wave. The temporal lobe of the brain is known to house many of the structures that are involved in language including the primary auditory cortex, implicated in semantic processing and part of Wernicke's area, implicated in speech comprehension (Baars & Gage, 2010). Therefore disruptions in the temporal auditory processing of the sound wave implicate language processing.

Intervention: contributions in neuroscience. Based on the assertion that a phonological deficit rather than a cognitive or linguistic impairment is at the heart of language learning disorders and that children with language learning impairments experience difficulty in processing the rapidly changing sensory inputs of the acoustic wave, Tallal et al. (1996) and Merzenich and colleagues (1996) have studied the effects of temporal modification of the acoustic wave. Following an audio-visual based intervention at a rate of three hours per day, five days per week in the laboratory and one to two hours per day, seven days per week at home for one month, seven five to ten year-old subjects demonstrated a two year increase in their receptive speech language skills on such tasks as speech discrimination, language processing and grammatical comprehension (Merzenich et al., 1996). The authors suggested that it was highly unlikely that children could have learned two years' worth of concepts during the one month study. They hypothesized that the children must have already acquired the concepts measured on the discrimination, processing and grammatical

comprehension tasks prior to the study but that the children were unable to express their knowledge intelligibly prior to the intervention (Merzenich et al., 1996). The training tools in this study involved use of two audiovisual games: a perceptual identification task and a phonetic element recognition task, both designed around a circus theme. Feedback on the audiovisual games occurred in the form of an audio or visual signaling, positive reinforcement when the child made a correct response. The children also accumulated points that could be traded for prizes in a token economy (Merzenich et al., 1996). Vygotsky (1962) suggests that learning is mediated through social interaction and that the child acquires concepts through the process of having an experienced other assign meaning to the child's behavior, including verbal behavior.

In the absence of an experienced other, two possibilities offer themselves:

1. The authors' hypothesis is correct and the children in the study had already acquired the language concepts but were not able to express them intelligibly prior to intervention.
2. The children did not in fact acquire concepts because concepts are scaffolded and layered; the binary (positive reinforcement or absence of response) feedback offered by the computer does not provide enough information to layer multiple patterns about an idea. The children therefore only appeared to have acquired concepts through the lens of the researchers' interpretation and in reality acquired numerous structural patterns that matched the patterns the children were evaluated on.

The discussion is significant because although not specifically targeted to the sCAS population, if the use of acoustically temporally modified speech to train the brain results in production of intelligible speech and language that is consistent with that of same-age peers in language impaired populations then the aforementioned intervention would be a significant inroad in treatment research in sCAS. However if the intervention does not result in increased language and cognition, then it will be insufficient to remediate sCAS if indeed sCAS results from a deficit in acquisition of semantic concepts.

Intervention: contributions in language. Noam Chomsky, an American Linguist, first suggested that every sentence in a given language contains two levels of representation, the surface structure and the deep structure (Chomsky, 1957). They are determined by semantic representation—semantic refers to the conceptual, thinking level of language—and well-formed surface structures are mapped by grammatical transformations (Chomsky, 1969). Surface structures are what are referred to as the syntax of language, what a person actually says, and are mapped into phonetic representations by phonological rules; surface structures are the syntactic form that deep structures, or concepts, take as actual sentences (Chomsky, 1969). Languages, then, consist of infinite sets of sentences that are constructed from a finite alphabet of letters or phonemes (Chomsky, n.d.). The grammar of a language “can be loosely described as a system of rules that expresses the correspondence between sound and meaning in this language” (Chomsky, 1969, p. 63). Phonological rules stem from the study of phonology, a branch of linguistics that deals with the relationships among

speech sounds in a given language, especially how they function to encode meaning. This is significant as meaning is the basis for acquiring speech; meaning therefore should also be the basis to intervention in speech sound disorders including sCAS. According to Chomsky's proposal that every sentence has two levels of representation, the deep structure gives the kernel structure of a sentence while the surface structure expresses the syntactic-phonological information. Chomsky suggests that the two are related as "properties of surface structure [such as phonological representation] play a distinctive role in semantic interpretation" (Chomsky, 1969, p. 116). The deep structure of language, its function, provides the foundation for the surface structures of language. However surface structures or forms do not provide the basis for thinking.

Evidence of literature gap in sCAS. At this time there is a literature gap that exists in the demonstration of methods of intervention for children with sCAS based on a language function lens. In the current model, sCAS is defined mostly in terms of the surface structures of language. The characteristics of verbal speech that are used to diagnose sCAS including articulatory slowness (Browman & Goldstein, 1989; Weismer et. al, 1995); abnormal scaling of articulatory gestures (Browman & Goldstein, 1989; Weismer et. al, 1995); variability of speech production/segmentalization (Weismer, et al., 1995); slow diadochokinesis (Yoss & Darley, 1974); omissions, revisions, additions in productions (Yoss & Darley, 1974) feature errors (phoneme prolongations, repetitions & distortions); (Yoss & Darley, 1974); absence of neuromuscular deficits (reflex, tone) (ASHA, 2007¹); errors in speech

sound production (ASHA, 2007¹); and errors in prosody (ASHA, 2007¹) refer to surface structures of language. The literature review has further revealed that sCAS stems from errors of perception (Stevenson, et al., 2011; Tallal et al., 1996; Yoss & Darley, 1974), phonological representation (Claessen & Leitao, 2012; Eulitz & Lahiri, 2004; Kent, 2000; Moriarty and Gillon, 2006; Shriberg et al., 1997) and motor planning (ASHA, 2007; Weismer et al., 1995; Yoss & Darley, 1974).

Using the definitions given by the American Speech Language Association, it was shown that sCAS is both a speech disorder as it affects the way children produce syllables and words (ASHA, 2007⁵) and a language disorder as it impacts the phonological system, a component of language in ASHA's definition (ASHA, 2007⁵). Interventions that focus on sCAS as a speech disorder target the patterns arising from the phonological system such as Sound Contrasts in Phonology (Williams, 2012), Hodson Phonological Cycles (Hodson, 2011) and distinctive features based approaches (Costello, 1975). On the other hand, interventions that focus on sCAS as a language disorder target lexical representations at the word level (Pinnow & Connine, 2014; Storkel & Morrisette, 2002). ASHA defines language in terms of form, content and function (ASHA, 2007⁵). The literature review demonstrated that language-based interventions targeted the surface structures of language but not the deep structure. This reveals a gap in the literature in consideration of sCAS as a language function based disorder.

The purpose of this research is to establish and define the parameters of what a language-based intervention in sCAS would look like based on practitioners in the

field who are currently making those translations from theory to application. In order to further support the theoretical underpinnings of what will be a proposed paradigm shift to viewing sCAS as a language-based disorder that manifests in impairment in speech intelligibility and impaired language function, a treatment of language theories will be needed.

Summary. Very little information is available in the literature that considers sCAS as a language disorder although it has been established through the ASHA definitions that sCAS is both a speech and a language disorder. Consideration of sCAS through the dual lenses of speech and language is this researcher's contribution; most researchers look at sCAS purely as a motor speech disorder. The absence of consideration of sCAS as a language disorder appears to be because in the scientific research literature, language is described in terms of the surface structures. The available literature suggests that language disorders are connected to disruptions in the phonological system, and that language learning disorders result from phonological deficits rather than cognitive or linguistic impairments. When language is considered in sCAS it is primarily in terms of the surface structures and primarily in terms of phonology, the system of sounds that comprises the language, bringing the research back full circle again to a speech based lens.

Summary of Assessment and Intervention in sCAS. Due to a lack of consensus on exclusive diagnostic criteria, there are currently no reliable assessment instruments for the diagnosis of sCAS, especially as a diagnosis separate from dysarthria (paralysis), phonological impairment, and other motor speech or speech

sound disorders. Although it is possible to assess symptoms such as phonological errors, articulation, or motor patterns, these do not yield a reliable diagnosis.

Intervention in the area of sCAS is primarily aimed at the patterns emerging from the phonological system and considers sCAS as a speech sound disorder with origins in phonological deficit and/or motor programming/planning but does not consider sCAS in terms of language function. A research gap exists in that sCAS is considered as both a speech and a language disorder but interventions in the literature primarily treat sCAS as a speech disorder; there is a lack of intervention literature considering sCAS as a disorder of language function. In order to create a bridge for the reader from the current state of the art in defining, assessing and treating sCAS as a speech disorder to the proposed idea of examining sCAS as a language disorder, a review of literature in terms of language theories follows.

Language Theories that Contribute to Understanding of the Disorder Suspected Childhood Apraxia of Speech (sCAS)

The purpose of this section is to provide an overview of the significant contributions in cognitive psychology, neuroscience and language that support interventions based on language function in sCAS.

Contributions in cognitive psychology. A research gap has been established that demonstrates there is a lack of understanding of sCAS as a language-based disorder with demonstrated functional differences in the brain, especially the temporal lobe. It has heretofore been treated primarily as a phonological or motor speech disorder.

Most of the interventions in sCAS work to remediate individual speech sounds and patterns of errors. This was demonstrated with distinctive features theory, for which interventions attempt to remediate errors across phoneme patterns (Costello, 1975). The Hodson Phonological Cycles approach, also presented in the intervention section of this review, deals with patterns of speech sounds arising from the phonological system known as phonological processes (Hodson, 2011). Merzenich's interventions focusing on temporal modification of the acoustic waveform also dealt with perceptual patterns (1996). Each of these interventions is consistent with the ASHA definition of language as "...rule-governed behavior, [that] is described by at least five parameters: phonologic, morphologic, syntactic, semantic, and pragmatic" (ASHA, 1982, para 3). However, a second definition of language was put forth by Arwood, "[a] conventional form of communication... [that] represents the underlying thinking processes as cognitive functions and the surface forms as imitated structures" (2011, p. 385). The difference in the definitions is that the latter expresses language not only as a behavior but also as a representation of thinking processes. In the latter definition, language is semantically based.

The cognitive psychology section reviews arguments presented by language theorists primarily in the late 19th and early 20th centuries whose understanding of language is aligned with the Arwood definition of language. These theorists provide the support for a language-based intervention in sCAS which deals with acquisition of meaning and thinking.

Language acquisition is a socially mediated process. Acquisition of language is a socially mediated process. The social constructivist theory, also known as socio-cultural historical theory, advanced by Lev Vygotsky, characterizes learning as a process that results from interaction between the individual and social and cultural conditions. In this model, social interaction is key to learning (Vygotsky, 1962). Although often ascribed to Vygotsky, the idea of scaffolding learning in the zone of proximal development, the distance between what a child can do independently and with support from a skilled other, was actually put forth by Jerome Bruner (personal communication, Julie Kalnin, October 29, 2014). In a control group experiment, children were exposed to mathematical concepts through play with manipulatives. It was found that the experimental group that received scaffolding support outperformed the control group, with no adult support for concept acquisition, in every measure. In this multiple baseline study, the controls made gains after the introduction of a meaningful context but when the context was withdrawn, there was no further gain. Repetition of concrete tasks did not lead to the ability to generalize or transfer a solution in the absence of a meaningful context. The authors concluded that

“Children alone cannot reliably ‘discover’ all the important and necessary knowledge and methods of action solely through manipulating the blocks. They learn these more effectively through carefully structured joint activity with ‘experienced others’” (Coltman, Petyaeva & Anghileri, 2002 p. 48).

The authors drew the conclusion that a meaningful context allowed for transfer of solutions. While other theorists of his time such as Stern asserted that language is discovered once and for all, Vygotsky understood that

“the grasping of the relation between sign and meaning, and the transition to operating with signs, never result from an instantaneous discovery or invention by the child” (Vygotsky, 1962, p. 27)

He asserts that language is learned over time as the child’s interactions with his environment provide opportunities for assignment and refinement of meaning by experienced others until he is able to use his language to assign meaning for himself (Vygotsky, 1962).

While the socio-cultural theory asserts that language is developed in a social context, other theorists posit that language is developed toward a social end: “Language is acquired as an instrument for regulating joint activity and joint attention” (Bruner, 1975, p. 2). Bruner further suggests that concepts are developed in mutuality with the speaker of the language (1975). Lenneberg corroborated the observation that language is learned over time noting that it actually correlates better with motor development, e.g., the products of the motor learning system, than with chronological age (1969).

As meaning is assigned to the perceptions of the child, he gradually moves from a state of considering the label a property of the object to grasping the sign-referent relationship (Vygotsky, 1962). Even before the advent of the neuroscience technology available today, Vygotsky theorized that this transition from an external

structure to an internal relationship was based on molecular changes in the brain. Overlapping patterns of sensory inputs do result in physiological changes in the brain through the dual processes of inhibition and integration whether this is through the formation of new networks or the inhibition of connections between neurons as in the theory of cogs, discussed below (Baars & Gage, 2010).

Concept acquisition forms the basis for speech production. “Speech cannot be discovered without thinking” (Vygotsky, 1962, p. 44). Just as Vygotsky asserted, speech production is a result of the process of acquiring concepts and language to name concepts. In order to learn words, use them appropriately in various situations, describe events and reports changes in internal state, a child must not only have a cognitive representation of what the word refers to but also a cognitive representation of the described events and reported states (Dore, 1979). This idea is supported by Chapman who asserts that speech production follows acquisition of concepts and emerges as a new means to express ideas the child already has.

“First, language acquisition follows a course in which *new meanings and communicative functions are first expressed by old means, or forms, of behavior*—whether gesture, vocalization, word, or sentence structure. Second, *new forms of communicative behavior typically emerge to express meanings and communicative intents already in the child’s repertoire.*” P. 33 (Chapman, 2000)

In an experiment regarding concept acquisition in which children were asked to group objects into categories it was found that the degree of ease or difficulty with

which the child could express in his own natural language the criterion for grouping correlated with the degree of ease or difficulty in attaining a concept (Lenneberg, 1962). Lenneberg suggested that words match a person's concept of reality, rather than the physical world (1962). He notes,

“...the child abstracts regularities or relations from the language he hears, which he then applies to building up language for himself as an apparatus of principles” (p. 164, 1969).

This suggests that language also affects cognitive processes. Lenneberg similarly draws a correlation between speech, language and cognitive processes,

“In tasks where language is the only possible (or most easily accessible) “information carrier,” language structure may affect cognitive processes” (pp. 108-109, 1969).

The Interactionist view suggests that new learning emerges from old patterns and new learning in motor, cognitive and social domains can serve as precursors to the emergence of new linguistic forms, which in turn can lead to subsequent development in other domains (Chapman, 2000). Each of the theorists supports the supposition that acquisition of concepts precedes verbal speech. This has implications for sCAS because the emphasis in the literature is on remediation of speech patterns. However if acquisition of concepts both precedes verbal speech and supports verbal speech then it may be relevant to look at the concept acquisition process as both a diagnostic indicator and a frame of reference for intervention.

The whole idea is greater than the sum of its component parts. Using the analogy of water putting out fire, Vygotsky explains that water is comprised of hydrogen and oxygen, the former of which burns and the latter of which feeds fire when considered individually. United however, they create a compound that both contains elements that are not present in the individual parts (e.g., the ability to put out fire) and do not contain elements that are present in individual parts (e.g., feeding fire). Similarly, Vygotsky (1962) asserts that speech, which he calls verbal thought and whose component parts are thought and word, cannot be considered in its component parts but must be considered as a whole entity in order to understand its function. This is aligned with findings in neuroscience which also demonstrate that whole ideas, or integrated circuits in the brain, are more meaningful than the individual neurons they are composed of. It has been shown that the temporal lobe is the site of word processing for language as well as integration of incoming sensory input for speech in the brain (Baars & Gage, 2010; Stevenson, et al., 2011). Asynchrony in the temporal lobe, leading to a lack of integration of the audio-visual speech signal, can result in phonological errors that are seen in sCAS.

The unit of analysis for verbal thought Vygotsky proposes is word meaning, or in other words semanticity. Vygotsky defines words as referring to groups or classes of objects, as generalizations. In this way it appears that he deals with the word, which he describes as a “microcosm of human consciousness” (p. 153) as the pattern and the word meaning as the concept. Considering the idea of a unit of analysis, Vygotsky notes that a unit (1) retains all of the properties of the whole and (2) cannot be divided

further without losing some of the properties of the whole. The idea of a whole being greater than its component parts can originally be attributed to Charles S. Pierce, the father of pragmatism, which is the study of semiotics (Arwood, 1983). Whereas more recent studies assign the phoneme, distinctive feature, morpheme or word as the unit of analysis, language theorists emerging from the late 19th and early 20th centuries considered the idea, or concept, the smallest meaningful unit of language. The concept is significantly larger than the parts of language that describe it, according to ASHA (1982): phonology, morphology, syntax, semantics and pragmatics. A concept embodies the parts of language.

Development is a product of learning. In contrast to Piaget, whose observations of his own typically developing children led him to postulate that all development must unfold as naturally as a seed unfolds into a flower in the right environmental conditions, Vygotsky believed that development is actually learned and does not unfold naturally without meaningful input. Neither does development precede instruction in academic subjects. He said

“Our study shows that the curve of development does not coincide with the curve of school instruction; by and large, instruction precedes development”
(P. 102)

Vygotsky demonstrates an understanding that social, language and cognitive development are intertwined and that development is a product of learning, which is named with language.

“Thought development is determined by language, i.e., by the linguistic tools of thought and by the sociocultural experience of the child. Essentially, the development of inner speech depends on outside factors; the development of logic in the child, as Piaget’s studies have shown, is a direct function of his socialized speech. The child’s intellectual growth is contingent on his mastering social means of thought, that is, language” (Vygotsky, 1962, p. 51).

Furthermore, Vygotsky notes that,

“The sensory materials and the word are both indispensable parts of concept formation. Studying the word separately puts the process on the purely verbal plane, which is uncharacteristic of child thinking” (1962, p. 52).

This suggests that children do not acquire concepts through verbal explanation alone but through interaction with the sensory information around them as the experienced other assigns meaning to the child’s behavior, including verbal behavior or speech. It was suggested in the previous subsection that the concept acquisition process could be a frame of reference for diagnosis of sCAS and a point of intervention. Vygotsky’s assertion that an experienced other must assign meaning to the child’s behavior, including speech, supports this vein of thinking. If an experienced other assigns meaning to the child’s speech, there is the possibility of changing the child’s speech as it results from conceptual understanding.

Vygotsky notes that

“memorizing words and connecting them with objects does not in itself lead to concept formation: for the process to begin, a problem must arise that cannot

be solved otherwise than through the formation of new concepts” (1962, p. 55, emphasis added)”.

As Vygotsky said, “direct teaching of concepts is impossible and fruitless” (1962, p. 83) because concepts are acquired. Moreover, a semiosis, or a reason, is necessary for a concept to take root, which Vygotsky expresses as a “problem” to be solved. This creates the need to know, which leads to the purposeful acquisition and ordering of perceptual patterns related to the problem, which are overlapped to form concepts.

Vygotsky asserted that

“Concept formation is the result of a complex activity in which all the basic intellectual functions take part. The process cannot, however, be reduced to association, attention, imagery, inference or determining tendencies. They are all indispensable, but they are insufficient without the use of the sign, or word, as the means by which we direct our mental operations, control their course and channel them toward the solution of the problem confronting us” (1962, p. 58).

The sign that Vygotsky refers to is the meaning of a word, which is named by language. Without language to name thinking, mental operations are meaningless.

As Vygotsky noted about trying to teach concepts,

“A teacher who tries to do this usually accomplishes nothing by empty verbalism, a parrot like repetition of words by the child, simulating a knowledge of the corresponding concepts but actually covering up a vacuum” (1962, p. 83)

Speech is representative of development. Pierce, Lenneberg and Vygotsky each dealt with the idea that a speech act signifies the speaker's whole development up to that time. Arwood stated "According to Pierce's semiotics a given instance of sign usage of language production reflects the entire process of development" (1983, p. 13). She gives the example that a child can be made aware of the convention of using an "-s" to denote plurality but won't use it functionally in his speech until it "represents a sign for which the child has such awareness" (1983, p. 11). A similar idea is found in Lenneberg's (1969) writings when he notes that children can only accurately repeat sentences that are formed from grammatical rules they have already mastered.

Just because a child demonstrates the verbal behavior doesn't mean the child has fully acquired the underlying concept. Leo Tolstoy (1962) also supported this argument, saying that as a child discovers a word he doesn't understand in the context of a reading passage that he does comprehend, and then overlaps this occurrence with other instances of use of the word in contexts he does understand, he comes to understand the word's meaning through the overlapping patterns.

"Word meanings are dynamic rather than static formations. They change as the child develops; they change also with the various ways in which thought functions...The relation of thought to word is not a thing but a process, a continual movement back and forth from thought to word and from word to thought" (Vygotsky, 1962, p. 124-125).

The patterns spoken of here relate back to the sensory input signals that travel as electrical impulses from the receptor organs of the body to the brainstem where they are either integrated and overlapped to form concepts or inhibited and discarded (Baars & Gage, 2010; Arwood, 2007).

Universal grammar. In the naïve psychology phase of the development of mental operations involving the use of signs, it is asserted that correct use of grammatical forms and structures occurs before the child understands the logical operations they represent. This is aligned with the theory of Universal Grammar, positing that there is an inherent acquisition capacity in the human brain to support language.

“Even in a child of school age, the functional use of a new sign is preceded by a period of mastering the external structure of the sign. Correspondingly, only in the process of operating with words first conceived as properties of objects does the child discover and consolidate their function as signs” (Vygotsky, 1962, p. 50).

The theory of Universal Grammar paired with Vygotsky’s assertions about the need for assignment of meaning from the experienced other to layer patterns for concept development, suggests that children can begin to use grammatical structures that represent thinking at or above their level of understanding. When meaning is assigned, the children refine their use and the concept is then deepened. This aligns with Arwood’s supposition that concepts are learned over time and can be deepened with increased understanding (2011).

Grammar is the synergistic interaction of the neural circuits which hold concepts and the symbolizing or naming of those concepts. There are six primary assertions in the embodied natural theory of concepts. These are: (1) information structure: semantic role structure, aspectual structure & certain hierarchical category structures needed for concepts are available at the neural level in the sensory motor system; (2) multimodality: mirror neurons, and some premotor and parietal neurons are multimodal; a single neuron may fire both for seeing the action of grasping and doing the action of grasping; (3) functional clusters: parallel parietal-premotor networks form clusters/high level units; (4) simulation: “imagination is mental simulation”; the same functional clusters are used for acting and perceiving (5) parameters: all actions, perceptions and simulations have neural parameters like directionality and force; the same hierarchical parameters that characterize the structure of actions and simulations also characterize the structure of action concepts; (6) structured neural computation: the same neural structures that carry out action carry out inference (Gallese & Lakoff, 2005).

The Theory of Cogs says that when we learn general cases, we are not acquiring new neurological structures but rather learning to inhibit connections between secondary and primary areas in the brain. The secondary areas behave in the same manner as the primary areas they are connected to. Special cases, related to secondary areas, inherently contain the generalizations of general cases because they are not newly acquired but rather separated by inhibition (Gallese & Lakoff, 2005).

Significantly, the implications of the Theory of Cogs and embodied theory of concepts is that there is no separate language module within the brain; rather language is built from the same brain structures used for perception and action, aligning with the domain specific hypothesis. Additionally, these theories posit that “grammar resides in the neural connections between concepts and their expression via phonology” (Gallese & Lakoff, 2005, p. 473). In other words, grammar, the ability to have a fully functioning language system, is an innate characteristic of the human brain as asserted by Chomsky with his language acquisition device. Grammar, or in this meaning language itself, exists in the synergistic interaction of the neural circuits which hold concepts and the symbolizing or naming of those concepts. This evidence aligns with the literature reviewed in the neuroscience subsection of the definitions in sCAS section of this chapter dealing with temporal synchrony, the perception of simultaneity of inputs. The perceptual fusion that occurs in the superior temporal cortex involves the “... physical temporal alignment of auditory and visual inputs” (Stevenson, et al., 2011, p. 7). When the inputs are integrated physically and fused perceptually or psychologically, audiovisual speech is perceived and the foundation is laid for the phonological representation which is one representation of a concept.

Agent-action-object relationships underlie all language grammars. Given that the propensity for grammar, or language, is an innate characteristic of the human brain the question begs whether there are properties among languages that are also innate and if so what the implications of these findings are. All natural languages have a topic-comment structure, expressed in English as subject-predicate (Bruner, 1975).

The primitive categories of grammar that are universal across languages are a) actions which are carried out by b) agents and have effects on particular c) kinds in particular d) places (Bruner, 1975).

Providing clarification to his original theory of case grammar, Charles Fillmore suggested that meanings are relativized to scenes and emphasized the role of agents in events. Fillmore noted with two example sentences that are acceptable in English “I hit Harry with a stick” and “I hit the stick against Harry” (1977, p. 75) that the former is more natural to native English speakers because in the latter sentence the manipulator, the agent wielding the stick, is left out of the perspective, yielding Harry as an inanimate object rather than a sentient being. Fillmore (1977) found that English grammar tends to include human beings rather than leave them out in favor of inanimate objects, a condition of saliency in perspective known as humanness. Noting that events are not limited in the number of active participants, Fillmore gave an example of a commercial exchange, explaining that verb choice would bring one or more entities of the event into perspective. If the seller and goods were to be brought into perspective, the verb “sell” would be used. By using the verb “spend,” the money and buyer are brought into perspective. “Pay” yields the perspective of the buyer and seller while “cost” brings the goods and money into perspective. When a sentence is constructed with any of the aforementioned verbs, the whole commercial event is brought to mind but the perspective of a particular aspect or section of the scene is put to the foreground based on what elements appear as subjects and direct objects in the linguistic expression (Fillmore, 1977). Accordingly, saliency conditions that favor

inclusion in perspective are humanness, change of state or change of location, definiteness and totality (Fillmore, 1977). Fillmore notes

“The point is that, whenever we pick up a word or phrase, we automatically drag along with it the larger context or framework in terms of which the word or phrase we have chosen has an interpretation. It is as if description of the meanings of elements must identify simultaneously ‘figure’ and ‘ground’” (1977, p. 74).

The significance of the commonality of agent-action-object relationships across grammars is that it provides a basis for intervention in sCAS. When looking at concept acquisition and errors in concept acquisition, the experienced other can assign meaning to the child’s speech, a representation of his thinking, by clarifying relationships based on the agent-action-object structure.

Pragmatics. The term pragmatics can be associated with multiple meanings. As part of the ASHA’s definition of language, it refers to language use and social aspects of communication (2007³). Arwood further defines pragmatics as “...the study of how language functions to represent social development” (2011, p. 389). She notes that “semantic principles govern pragmaticism” (Arwood, 1984, p. 27) and that problems in acquiring semantic relationships, the deep structure of language, underlie pragmatic deficits.

Describing the conditions that led to a need for the study of pragmatics, Arwood explained that principles of behavior science and psychology were combined

in the 1950's to develop theories and principles of learning which comprise a paradigm known as behaviorism (1984). Tenets of this paradigm were applied to children who demonstrated delays in speech and language acquisition, "if the learning principles were applied to speech, children could be taught to talk... chaining of sound sequences, void of thought and void of communication was emphasized" (Arwood, 1984, p. 10). Resultant to this emphasis on sequencing sounds out of context, children acquired the ability to produce utterances without language. Learning scientists then looked to Chomsky for his descriptions of language products, which were void of communication and thought, and used them for planning remediation programs.

Arwood explains,

"The study of pragmatics has taken two approaches: one approach deals with static components and the other approach takes a dynamic unit, the speech act, and uses it to analyze not only the speaker's components but the relationship of consequences" (p. 12, Arwood, 1984).

Products of the learning system such as turn taking, use of pause, eye contact and prosody are some of the static components referred to. Interventions described in this literature review have dealt with the static components of communication and the summaries have concluded that there is a gap in the literature in reference to the dynamic process of language.

Discussing the dynamic system of language, Arwood draws heavily on two theorists: Peirce, who developed a theory of signs and Searle, who explained the

interrelations of signs through the discourse system in his Speech Act Theory (Searle, 1969).

Peirce and signs. There are three types of signs: icons which are likenesses, convey ideas that they represent but are the actual objects being represented; indications or indices mark relationships between things and symbols, also called general signs, are associated with their meanings by usage (Arwood, 1984; Peirce, 1894). To account for the feeling, sensation, experience and conceptualization of signs, Peirce developed the categories of firstness, secondness and thirdness (Merrell, 2001). The categories describe the process by which signs emerge. “The use of a sign, (non-verbal or verbal) is based on the user’s underlying knowledge representing the sign” (Arwood, 1984, p. 5). This aligns with the ideas asserted earlier in this review by Lenneberg and Vygotsky that speech represents development.

Speech act theory. Speech act theory deals with the dynamic process of relating signs to users and interpretants (Arwood, 1984). According to Arwood (1984) Austin first proposed that there were three types acts: locutionary, illocutionary and perlocutionary, dealing with the utterance and propositions, the performance aspect of an utterance and the effect on the hearer, respectively. In 1969, Austin’s work was expanded on by John Searle who provided rules that specified the conditions of a successful speech act and separated out the utterance act from the propositional act. John Searle proposed that a speaker can perform three types of acts: an utterance act, a propositional act and an illocutionary act. The utterance act refers to the use or performance of symbols such as morphemes into sentences. The significant difference

between the utterance act and the propositional act that Searle defined is that the latter consists of various levels of referring and predicating; it refers to the content of the utterance or proposition (Arwood, 1984). Therefore, the utterance act can be performed through imitation such as the sequencing of sounds without meaning but the speech act, like Peirce's symbols, necessitates a meaningful exchange between a speaker who intends a message and a hearer or in the terminology of Peirce, interpretant, who perceives and interprets the message. Furthermore, the utterance act can be said to correlate with the surface forms that representation language while the speech act is a performance representing the underlying meanings of language.

Summary. Language acquisition is a socially mediated process in which an experienced other assigns meaning to the learner's behavior through a symbolized language system. The learner overlaps the patterns of sensory input from his environment with the meaning assigned to acquire concepts. Concept acquisition provides a basis for speech production. The meaningful unit in language is the concept, idea or word meaning. All development is a product of learning, and does not precede instruction. Speech acts represent the sum of a person's development at the time of the utterance. All of this suggests that in sCAS, the disordered speech represents what the child has acquired from the information presented and points to a use of meaning as an intervention point.

Bridging theories, it is suggested that context is created by agents carrying out actions with objects; events are comprised of multiple agent-action-object relationships. Working with an event to create a shared context with the learner is one

way to intervene in sCAS. The particular words and phrases that are used to express the underlying ideas activate the neural structures that perceived and stored the concepts. This is a strength in sCAS because one can identify what patterns of sensory input are being processed by the concepts that the child has learned, such as motoric concepts and what patterns of input are not being processed by the brain due to a difference in function by the differences the child presents with such as auditory language and speech production differences. Language is learned, as are all concepts, through the scaffolding and layering of patterns by assignment of meaning from an experienced other in response to the actions or behaviors of the learner, suggesting that it is possible to intervene in sCAS to remediate the speech sound disorder by addressing the child's conceptual language.

Two significant ideas have been established in this section regarding intervention in sCAS. First, that not all brains process information from the acoustic wave in the auditory cortex for concept formation and second, that a child's speech act represents his learned development up to that time. Taken together, these ideas indicate that the errors in sCAS point to a disordered acquisition of auditory patterns for conceptual learning. It was also previously stated that concepts require overlapping patterns and shown that in the absence of auditory patterns, visual patterns are needed to support language. Thus the question arises, how can meaning be assigned to individuals with sCAS in a visual, semantic way that promotes growth of language function? The neuroscience section that follows reviews literature that ties the hand to the brain for semantic intervention. The following language section then assimilates

that literature with information brought forth in this section regarding event-based contexts to support a theory known as the Neurosemantic Language Learning Theory (NLLT) (Arwood, 2011) for speech, language and learning intervention.

Contributions in Neuroscience. The neuroscience subsection of the definitions in sCAS section above established that temporal synchrony, the ability to perceive two distinct inputs of audiovisual speech which are the acoustic wave and the visual wave as a gestalt is not present in all brains. The assessment and interventions section concluded that there is a gap in the literature regarding language-based interventions in sCAS. The purpose of this section is to establish a link between the movement of the hand and the movement of the mouth for the acquisition of language and production of speech, through the neuroscience literature. This has implications for treatment in the acquisition of semantic features for learners whose brains do not integrate acoustic and visual information to form auditory perceptions.

Evolutionary connection. One theory that has been advanced in the neuroscience literature is of an evolutionary connection between the use of the hand to create and implement tools and the development of human speech. This relationship is considered phylogenetic, based on natural evolutionary relationships (Meister et al., 2003).

Motor control. There is a motor aspect to the surface forms of speech, as in motor speech disorders, different than the underlying meaning. Examining the literature on the use of the hand provides some connections between the mind, the brain, motor development and concept development. Neuroscience literature has

demonstrated a connection between the hand and speech based on increased excitability in the hand area of both hemispheres during spontaneous speech. (Tokimura, Tokimura, Oliviero, Asakura, Rothwell, 1996 in Meister et al., 2003).

Reading aloud has no effect on the excitability of the primary motor hand area in the non-dominant hemisphere and no effect on the leg area of either hemisphere. Reading aloud does however increase excitability in the primary motor hand area of the dominant hemisphere; the excitability is absent before and after articulation. In other words, its occurrence is limited to the time during the execution of the reading task (Meister et al., 2003). Although a false dichotomy may be created when trying to separate the articulation act of speaking from the cognitive and processing tasks that also underlie reading, a connection is here established between the motor cortex areas implicated in hand and speech control. Because the dominant hemisphere primary hand area, and not the leg area—ruling out generalized motor overflow effects—is more excitable during reading and priming for reading but not during non-speech vocalizations, there is evidence for a connection between hand movement and spoken language (Meister et al., 2003). Leighton and Heyes also found an automatic imitation or movement compatibility effect in a study of effector and movement compatible and incompatible stimuli on hand and mouth movements (2010). The implication is clear: the mechanisms underlying imitation of motor movements cross systems, at least between hand and mouth movements. This is further evidence in support of the use of the hand to create semantic meaning as an intervention for motor speech disorders, e.g., sCAS. That the hand-mouth-brain connection has been established for reading but

not non-speech vocalizations suggests a semantic difference, the difference between speech which is the surface structure of language and language itself, the underlying deep meaning. The implication may be that movement of the hand for language-directed tasks impacts concept formation and organization, which is thinking, and thus supports verbal speech.

Another experimental study looked specifically at the link between oral and hand movement as a function of speed. In the experimental study, 11 children with speech sound disorders age four years, seven months to six years, six months and 11 gender and age matched controls were assessed. Although no statistically significant group differences were found, indicating that speed is probably not a significant predictor, oral and hand movement speeds were associated, suggesting a motor system control mechanism that transcends domains (Peter, 2012). Whereas other theoretical frameworks have posited that the speech motor control system is separate from other motor control systems such as the limb movement system, this research suggests there is evidence for a central mechanism that crosses domains for motor movement. The implication may be that purposeful movement of the hand could aide in overcoming the motor programming/planning aspect of sCAS.

Mirror neurons/structures. That language and gesture depend on similar neural systems has been posited in the gesture theory of language and supported by findings from aphasic patients using gesture to accompany speech (Hadar, Wenkert-Olenik, Krauss & Soroker, 1998). Several findings of significance are based on their theory. Mirror neurons in monkeys discharge when they observe a human grasping

food as well as when the monkey grasps food itself, even when the monkey is in the dark and cannot see his own hand action. However the mirror neurons in the monkey do not discharge when he observes a human grasping food with a tool. Individual mirror neurons are dedicated to certain movements and most have only one movement that they respond to, although some have two and very few have many. Those in the latter category are activated in response to “object directed motor acts” (Arbib & Rizzolatti, 1996, p. 396). Significantly, this observation system is also present in humans. The area of the human brain that corresponds to the area of the Macaque monkey’s brain where this mirror neuron activity is seen is known as Broca’s area (Meister et al., 2003). Broca’s area, located in the left inferior frontal gyrus, in the left temporal area of the brain contains mirror neurons that represent hand movements as well as bucco-laryngeal speech (Meister et al., 2003). Broca’s area has a somatotopic organization; its fundamental capacity is to match observation and execution (Arbib & Rizzolatti, 1996). These findings suggest that the human brain is designed to record and process movement of all types and especially movement of the hands and articulators, which may facilitate acquisition of perceptual patterns related to eye, hand and mouth movements. The next section reviews literature related to the eyes and visual processing specifically.

Visual Processing. Studies in populations with sensory impairments have yielded further understanding of the interplay between visual processing and language in the brain. In an investigation of processing speed among deaf individuals proficient in American Sign Language, Emmorey found that the time to identify phonological

movement on the mouth did not differ from the time to identify signs on the hands (1993). Hand shape, orientation and location were identified almost simultaneously at 170 milliseconds, with signs identified visually at 240 milliseconds versus 330 milliseconds to isolate a spoken word (Emmorey, 1993). The study suggested that language modality affects the speed of lexical identification and that visual modality has the advantage.

A study of blind subjects reading braille used Positron Emission Tomography (PET) to determine whether the visual cortex receives input from the somatosensory system. Blind subjects demonstrated activation of both primary and secondary visual cortical areas during tactile discrimination tasks while those areas were deactivated in seeing subjects. Braille reading by blind subjects activates the occipital lobe while non-discrimination tasks did not activate the visual cortex in either blind or sighted subjects. These findings suggested that somatosensory input could be transferred to the primary visual cortex through the visual association areas during Braille reading by blind subjects (Sadato et al., 1996). In another study of the visual perception of deaf children the authors concluded that “the motor cortex is prominently involved in the elaboration of visual sensations into perceptions” (Myklebust & Brutton, 1953, p. 34).

It was once thought that visual, auditory and somatosensory domains of the brain were exclusively populated by modality-specific neurons that responded only to single sensory modality inputs. Researchers found however that each domain is subject to influence from inputs originating from other senses. They attribute this

finding to multisensory neurons populating the borders of each domain whose modality profile matches the representation in the neighboring cortices and are which are able to integrate cross-modal inputs to give rise to enhanced or depressed inputs (Wallace, Ramachandran & Stein, 2004). Neurons which are responsive to non-visual inputs have been found in the visual cortex, a finding which may help to explain the activation of the visual cortex in blind subjects reading Braille.

Summary. An evolutionary connection between the use of the hand to create and manipulate tools and the emergence of human speech has been developed. It is known as a phylogenetic relationship. Studies investigating hand and speech control and oral and hand movement speeds support the supposition of a central mechanism that transcends domains for control of motor movement. Mirror neuron studies in macaque monkeys are activated in response to movement of their own hands or observation of human hands grasping food, but not when the grasping is mediated by a tool. They require an interaction between an agent, who performs an action, and an object, to which an action is done (Arbib & Rizzolatti, 1996). When multiple agent-action-object relationships are overlapped within a common, specified context, an “event” is said to have taken place (Arwood, 2011). The mirror neuron area in the macaque brain correspond to Broca’s area in the human brain which is implicated in matching observation and execution and has mirror neurons that respond both to hand movement and to bucco-laryngeal speech, further supporting the hand-speech connection for neural activation.

Based on the all or nothing law of the action potential, a neuron must reach its full action potential in order to fire; it does not fire partially given insufficient activation (Baars and Gage, 2010). Inhibition and integration work in the brain to develop structural groupings of neurons, circuits and networks that function together. The implication for a motor hand-area neuron being increased in its excitability, which means a lowering of the action potential threshold and an increased readiness to fire, is that in this possible two-way connection movement of the hand could decrease the firing threshold for neurons activated for speech. This becomes particularly important when considering phonological inhibition based on neighborhood density and word frequency discussed in the language section above.

Contributions in Language. A literature gap has been established regarding the use of a language lens to assess and treat children with sCAS. Contributions in cognitive psychology have provided a theoretical foundation for language acquisition and use. Contributions in neuroscience have provided a link between the hand and mouth on which principles of intervention can be based. The review will now turn to a theory which correlates with the above evidence and provides a theoretical framework for assessment and treatment in sCAS as a language disorder.

Neurosemantic Language Learning Theory. The Neurosemantic Language Learning Theory (NLLT) is a four level model of learning (Arwood, 2011). At the first level input is received from the sensory receptors, which are the skin for pressure, the nose for smell, the taste buds for taste, the ears and eyes for hearing and vision. Specifically the ears receive the properties of the sound wave, which are

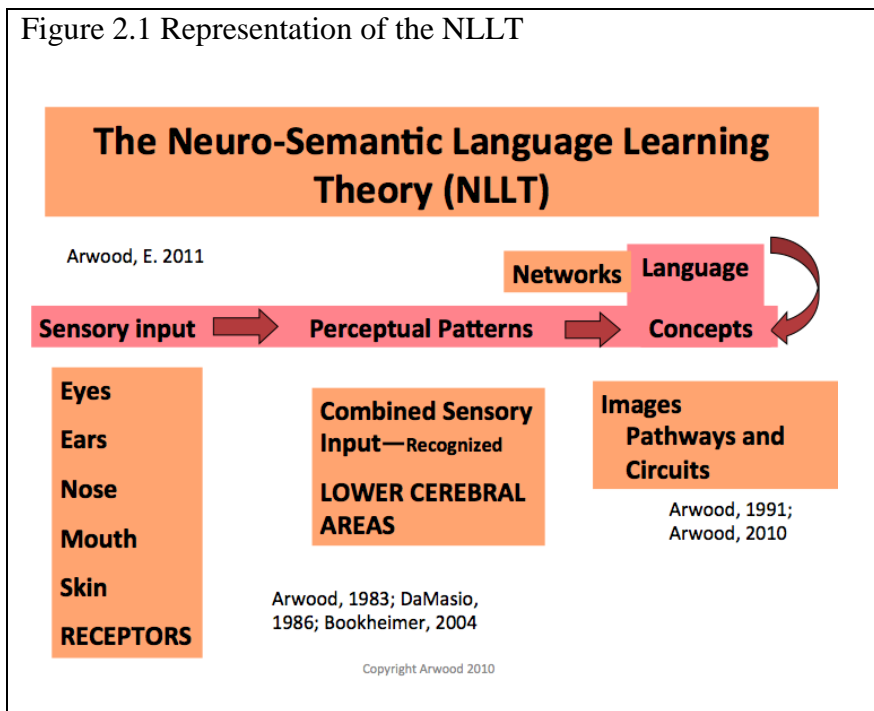
(property/psychological correlate): distance/time, amplitude/loudness, and frequency/pitch. The eyes receive the properties of the light wave as a light source such as the sun or a lamp heats the air causing photons to spin off and on the edges of objects, which are reflected, back to the eyes. These properties are light and movement (Arwood, 2011; Baars & Gage, 2010). The all or nothing law of the action potential was discussed in the neuroscience section above. Coupled with the implication of a motor-hand area neurons being increased in excitability and lowering the firing threshold for neurons activated for speech, this principle suggests that when a child's neurobiological way of learning is identified, the patterns of sensory input can be changed to match their learning system (auditory or visual) to layer concepts for thinking. The NLLT posits that humans do not learn words but rather acquire the semantic features of sensory input overlapped to form concepts through perceptual patterns. All acquired patterns for learning must be overlapped. Given the available choices for overlapping perceptual patterns, which is the second level of the NLLT, acoustic layers cannot be overlapped for language because they create only echolalia; this is borne out in the field of linguistics which evidences that there are no productive languages in the world which are solely based on acoustic properties (Arwood, 2007; personal communication, E. Arwood, September 20, 2014). The alternative options are to overlap the properties of the acoustic wave with those of the visual light form wave to create a way of thinking that is auditory in nature. In this model, sensory inputs are integrated at the level of the auditory nerve for processing. When sensory patterns are not integrated at the level of the auditory nerve, the remaining option for creating

overlap of patterns is visual on visual layers. Several researchers demonstrated that the breakdown in the language system for children with speech sound disorders occurs as an impairment in temporal processing of the auditory stimulus at the input level (Merzenich, 1996; Shriberg et al., 1997; Yoss & Darley, 1974). In other words, children with SSDs don't experience temporal synchrony; they are not able to process visual and acoustic inputs simultaneously. This is supported by findings from Stevenson et al. (2011) regarding a lack of temporal synchrony in the superior temporal cortex. By default, these children use the visual patterns to form images in the pathways that cross hemispheres.

In whichever way the individual's neurobiological learning system functions, whether it is with visual or with auditory patterns, sensory patterns overlap to form images. This can only happen as meaning is assigned from the outside to the perceived patterns so that the brain begins to recognize and integrate new patterns and inhibit those that have already been recognized. In this way, concepts are acquired or learned but cannot be taught. Concepts are literally, as Vygotsky (1962) hypothesized, a change in the molecular structure and function of the neurons in the brain, as they reorganize into semantic connections called circuits and larger formations called networks that are activated in response to certain patterns (Arwood, 2011; Baars & Gage, 2010). In the NLLT, overlapping sensory patterns are physiological brain changes through the integration and formation of new networks and/or the inhibition of connections between and among neurons as in the theory of cogs (Gallese & Lakoff, 2005). At the concept or image development level, it was suggested that any

intervention that is directed at a higher level of thinking in the brain affects the areas beneath it as a result of feedback mechanisms. This was supported by work done at the morphosyntax and phonological levels of speech processing where the morphosyntax intervention affected phonological outcomes and the reverse was not true (Tyler et al., 2002). Finally, when a threshold of concept development is reached, language, an abstract symbol system, can be used to name the concepts and to facilitate further conceptualization. As stated above, language exists in the synergistic interaction of the neural circuits, which hold concepts and the symbolizing through the networks, or naming of those concepts via phonology (Gallese & Lakoff, 2005). There is interplay between the third and fourth levels of the NLLT as concepts are both named by language and are created and/or expanded through neurosemantic integration and inhibition (Arwood, 2011). Quoting Tolstoy, Vygotsky (1962) spoke of the acquisition of meaning as a dynamic process that changes based on the way that the child functions as he learns. This demonstrates the overlapping spiral nature of learning and the interaction between the third and fourth levels of the NLLT where concepts are named by language and language is used to expand on and create new concepts. It also reflects the process of engagement between the learner and an experienced other where the experienced other presents an idea that is preoperational to him, and concrete to the learner. The learner acquires the semantic properties of the presentation of this thought (whether they be visual or auditory properties depending on his neurobiological learning system) and the learner forms a thought which he

expresses through language, the word in this analogy, which is concrete to the experienced other. Through this back and forth exchange meaning is negotiated.



Paradigm shift. Based on what we know about neurobiology, language as an artifact of the mind, how we learn in terms of semantic features acquisition and pragmaticism philosophy, the Neurosemantic Language Learning Theory (NLLT) is the theory that best fits the research questions which follow at the end of this section. It has been demonstrated that people with sCAS experience language delays as a result of poor auditory perception and lack of temporal synchrony (Merzenich, 1996; Shriberg et al., 1997; Yoss & Darley, 1974). This population presents with an impaired ability to create phonological representations for semantic ideas (Shriberg et al., 1997 p. 731 as cited in Moriarty and Gillon, 2006). Because overlapping layers of

perceptual patterns are necessary to create new concepts (Arwood, 2011) and the semantic features of the acoustic wave are not integrated for processing in this population (Stevenson et al., 2011), the semantic features of the visual wave are used to acquire concepts (Baars & Gage, 2010; Arwood, 2011). Learning occurs when an experienced other assigns meaning in a way that matches patterns used by the neurobiological learning system, in this case visual patterns, to form concepts (Arwood, 2011; Vygotsky, 1962). In order to overcome the disadvantage of similarity of sound provided in a phonological intervention, it is necessary to provide adequate context on which to frame new learning; this context can be created through a semantic event that encompasses multiple agents performing actions in relation to both objects and other agents (Arwood, 2011; Fillmore, 1977). Having established the principle that in populations with sCAS, information will be provided visually, the question becomes one of what qualifies as a visual semantic feature. Viconic Language Methods (VLMTMs) including but not limited to cartooning, pointing, signing, fingerspelling, writing, speaking, viewing, pictographing and indexing, independently or hand-over-hand are considered means of providing visual semantic layers of information (Arwood, 2011). As the visual information is acquired through the sensory receptor organs including the movement of the hand, it is theorized that the brain of the person with sCAS will demonstrate a lowered firing threshold for speech (Meister et al., 2003; Peter, 2012). By creating a meaningful context, the event, not only is feedback provided neurologically to lower processing areas such as those used for speech production (Tyler et al., 2002) but through the refinement of the

surface structures as written language to match the ideas as drawn or cartooned concepts and pictographs, the neural connections between the properties of the surface structure, namely the accurate phonological representation and the semantic interpretation are strengthened (Chomsky, 1969).

The subject of this study is to determine if the triangulation of literature to support a neuroeducation lens will provide some direction as to how to intervene with children with sCAS. The subsequent study undertakes the question of what people say they do when they intervene in sCAS using a neuroeducation framework.

Based on the literature contributing to a neuroeducation lens, it is theorized that

1. People with sCAS have a visual neurobiological learning system resultant from the lack of integration of sensory inputs at the level of the temporal auditory nerve (Stevenson et al., 2011; Yoss & Darley, 1974). Therefore they require overlapping visual inputs in order to learn (Arwood, 2011).
2. As a result of the lack of integration of sensory input, people with sCAS are not able to match the sound of what they hear spoken with what they see represented, leading to an impoverished phonological representation of ideas (ASHA,2007; Claessen & Leitao, 2012; Eulitz & Lahiri, 2004; Moriarty & Gillon, 2006).
3. People with sCAS are unable to effectively manipulate the individual phonemes of the sound system of language to represent meaning due to an impoverished phonological representation (Moriarty & Gillon, 2006).

4. The language system in the brain is represented in the same neural circuits and networks that represent the domain specific sensory input (Caramazza & Mahon, 2003).
5. Manipulation of domain specific sensory input to increase meaningful visual patterns to create an event will result in top-down changes in the brain that make clear speech possible (Arwood, 2011).
6. Movement of the hand for drawing concepts connected with writing the patterns that name concepts will be a significant contributor to the means by which the linguistic system and lexical representation will be enhanced in persons with sCAS (Arwood, 2011). This is supported by evidence demonstrating the link between hand movement and spoken language (Leighton & Heyes , 2010; Meister et al., 2003; Peter, 2012).
7. People with sCAS receiving treatment through the NLLT will be enabled to perform the speech act as an imitation gesture after adequate conceptualization has occurred to support the language representing the ideas which the person chooses to speak and which he has not heretofore been able to speak as he has had to rely on a faulty phonological representation system which has inhibited his conceptual development.

Summary. The Neurosemantic Language Learning Theory (NLLT) is a four level theory advanced by Dr. Ellyn Arwood (2011) that provides a theoretical framework for the assessment and treatment of children with sCAS based on consideration of their visual learning systems by aligning perceptual patterns with

their neurobiological way of learning for the acquisition of concepts. By aligning the findings in research literature and using the NLLT as a theoretical framework, a paradigm shift can be made from considering sCAS primarily as a motor speech disorder and treating it through the isolation and manipulation of sound to considering sCAS as a language function based disorder and treating it through the remediation of the underlying language system.

Summary of Contributions of Language Theorists

Theorists such as Pierce, Lenneberg, Vygotsky, Dore and others have contributed to the understanding of language acquisition as a process which culminates in verbal speech that represents the speaker's development. Neuroscience literature connecting the movement of the hand to the movement of the mouth for speech helps to fill a gap created by the recognition that not all brains process audiovisual speech with temporal synchrony and while brains can be trained to use sound (Merzenich et al., 1996), the underlying mechanism for concept acquisition cannot be changed to match the auditory input. The NLLT, a four level theory developed by Ellyn Arwood (2011) aligns with findings from the cognitive psychology, neuroscience and language domains to provide a theoretical and conceptual framework for the assessment and intervention of sCAS as a language based disorder.

Research Questions

A research gap has been identified in the definition, assessment and treatment of sCAS as a language-based disorder. Theoretical underpinnings of language have

been discussed which align with the NLLT. Viconic™ Language Methods (VLMs) are the methods which are associated with the NLLT which facilitate a visual thinker to translate visual cognition to auditory English (Arwood, 2011). In addition to establishing, a neuroeducation foundation to assessment and remediation of sCAS as a language disorder; the second purpose of this study is to determine whether a treatment based on NLLT provides efficacy of using a language-based approach for sCAS as reported by educators who use such beliefs and intervention methods.

Specifically,

1. Will Speech Language Pathologists (SLPs) and educators with a theoretical background in the NLLT; and, who report using neuroeducation-based methods with their clients, with sCAS or speech sound disorders respectively; also report positive client outcomes for both speech intelligibility and language function?
2. To what degree will Speech Language Pathologists (SLPs) and educators who report using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively report use of methods that align with the NLLT?

Chapter Three: Methodology

The previous chapter contained a review of the literature to determine whether a triangulation of the literature will provide some clues as to whether or not a neuroeducation approach to intervention with sCAS is feasible. This chapter contains a discussion of the research design, population and participants, instrumentation, data collection procedures, methods of data analysis, validity and reliability.

Re-Statement of Purpose

The purpose of this study was twofold, first to explore the pertinent cognitive psychology, neuroscience, and language literature that surrounds the diagnosis and treatment of children with Suspected Childhood Apraxia of Speech (sCAS) with the intent of finding a translational neuroeducation approach to the treatment of sCAS. Second, while traditional treatment is aimed at the acoustic motor patterns of phonological processes, this study sought to uncover what professionals who have some neuroeducation training say they do when they treat children with sCAS.

This research was undertaken in three component parts. The first part involved a triangulation of the literature in cognitive psychology, neuroscience and language to suggest a new approach, rooted in neuroeducation, to the diagnosis and treatment of suspected Childhood Apraxia of Speech (sCAS). The reason for looking for a new approach in sCAS was rooted in the researcher's experience with limited treatment effectiveness based on current models of intervention. The literature supported a research gap in the identification of sCAS as a language-based disorder without corresponding intervention methods. Specifically, Chapter Two provided an analysis

and synthesis of the literature about what defines sCAS from a neuroscience, cognitive psychology, and language perspective. The results of this literature suggest that the surface problems- phonology, morphology, syntax- are mapped onto a semantic basis. This semantic basis is feature-based and people with speech sound disorders are likely to use a visual semantic feature basis. So, the literature supports a shift to a new lens that aligns with the Neurosemantic Language Learning Theory (NLLT) and that could be the basis for intervention in sCAS. The researcher then asked whether this intervention is effective according to the perceptions of those SLPs and educators who report using intervention methods based on principles of neuroeducation, with their clients with sCAS or speech sound disorders, respectively. The literature used to support the paradigm shift to neuroeducation was reviewed in Chapter Two and the triangulation, an outcome of the literature review, is presented in Chapter Four, results.

The second part of the study involved interviews conducted with Speech Language Pathologists (SLPs) and educators currently using principles of neuroeducation to treat children with sCAS in order to uncover the methods that they report having used in interventions with this population. The interviews, along with the artifacts provided by interview participants, serve as confirmatory evidence to the findings from the literature review by demonstrating the reported change in children over time as a result of the intervention. The steps are discussed in this chapter. Finally, the third component of the research involved evaluating the intervention steps that the interview participants reported to uncover whether there was a semantic basis,

parallel with the literature, to the intervention in conjunction with analysis of the artifacts. This step was taken because the literature review in chapter two revealed a gap in identifying sCAS as both a speech and a language disorder while most intervention studies treated it only as a speech disorder. The triangulation of literature, reported in Chapter Four, suggests that use of a neuroeducation lens will include a semantic basis to intervention so this was considered as an indicator that the participants were using a neuroeducation lens.

These steps are reviewed in this chapter and the results are presented in Chapter Four.

The research questions asked were:

1. Will Speech Language Pathologists (SLPs) and educators with a theoretical background in the NLLT; and, who report using neuroeducation-based methods with their clients, with sCAS or speech sound disorders respectively; also report positive client outcomes for both speech intelligibility and language function?
2. To what degree will Speech Language Pathologists (SLPs) and educators who report using methods based on principles of neuroeducation, with their clients with sCAS or speech sound disorders, respectively; report use of methods that align with the NLLT?

Research Design

This was a qualitative research study. According to Merriam (2009), “A central characteristic of qualitative research is that individuals construct reality in interaction with their social worlds” (p.22). Qualitative research is designed to uncover and

interpret the meanings that people assign to their lives. In order to understand the specific methods that comprise a language-based intervention for sCAS and how they are implemented in the therapeutic or educational setting, interviews were conducted with Speech Language Pathologists (SLPs) and educators who self-report use of visual semantic methods for treatment of sCAS. An interview is a conversation, typically a face-to-face encounter, with a purpose in which one person, the researcher, elicits information from another person, the subject, which cannot be readily or easily observed (Merriam, 2009). Although intervention methods with sCAS clients could be observed, issues of confidentiality and anonymity as well as variables of difference among clients and therapists could not be considered given the time frame to complete the study. Therefore interviewing was considered an expedient method to gain information from multiple sources in order to strengthen the validity of the mined data. Types of interviews include broadly, highly-structured, semi structured and unstructured, or informal. In this study, semi-structured interviews were used with a structured component for demographic information. The semi-structured interview format allowed the researcher to use questions flexibly to be responsive to the interviewee. See Appendix A for schedule of interview questions.

The use of interviews as a qualitative tool allowed the researcher to understand the lived experience of a population under study, in this case the experience of SLPs and educators, who used an intervention approach based on the triangulation of the literature for those with sCAS, not previously reported in the literature. Following interview analysis, selected artifacts submitted by interview participants were

analyzed to substantiate the findings regarding the efficacy of the reported treatment methods by SLPs and educators treating students with sCAS or speech sound disorders.

Population and Participants

Purposive sampling, which aims to illuminate the relationship between language intervention strategies based on the visual learning system and improvement in sCAS, was used in this study. A biased sample was chosen based on participants' having self-reported use of the Neurosemantic Language Learning Theory (NLLT) or associated methods (Viconic Language Methods) in intervention with children with sCAS or speech sound disorders and having participated in continuing education on these topics.

Interviewees were selected based on participation in continuing education related to visual strategies for language intervention. Currently practicing Speech Language Pathologists (SLPs) were chosen to be interviewed because the treatment of sCAS falls within the scope of practice for SLPs (ASHA, 2007³). The decision to also include educators who are using VLMs was based on the expected small sample size and the hypothesis that educators may report not referring to SLPs when working with children with speech sound disorders using language-based interventions because the speech intelligibility clears up without referral. All interview participants were English speaking, resided in the United States of America, and had association with APRICOT, Inc., the provider of continuing education in the area of neuroeducation

using the NLLT. A verbal announcement was made requesting interviewees at an APRICOT workshop and subsequently printed in an APRICOT newsletter.

Eleven SLPs, one speech-language pathology assistant (SLPA) and four educators were originally contacted and asked if they would be willing to participate in this research study. Two SLPs declined based on their not having used the principles or methods associated with the NLLT in intervention with children with sCAS. Two additional SLPs were recommended to the researcher by participants and were contacted and asked if they would be willing to participate in this research study; one was subsequently interviewed. All currently practicing research participants who were SLPs held state licenses in their fields. Two SLPs working in public schools did not hold a current national certification with the American Speech-Language Hearing Association (ASHA); the remaining six did. Both SLPs and educators self-reported that they used the NLLT or Viconic Language Methods with children with sCAS, if they were SLPs, or with children with speech sound disorders, if they were educators. All research participants gave verbal consent prior to the interview and signed a written consent before or after the interview was complete. Following the interviews, one interview was omitted from data analysis because signed consent could not be obtained after three attempts to contact the participant. Two interviews were omitted from data analysis because the data revealed that the individuals did not use the NLLT or VLMs as the basis of their intervention with children with sCAS. Interview transcripts from a total of thirteen participants including seven SLPs, one SLPA and five educators were included in the data analysis.

Interview participants included, in the final data analysis, had an average of 26.5 years of experience for SLP/SLPAs and 18.4 years for educators, 367.5 hours of continuing education credits for SLP/SLPAs and 293.4 hours for educators, 5.6 graduate level University credits in Neuroeducation for SLP/SLPAs and 10.2 for educators. Among the SLP/SLPAs, one worked in private practice, four worked in public schools and three were retired, having previously worked in public schools. Among the educators, two worked in private practice and three worked in public schools.

Table 3.1 Years of Experience of Participants

Years of Experience		
SLP/SLPAs	Mean	26.5
	Median	26
	Range	7 - 48
Educators	Mean	18.4
	Median	12
	Range	10 – 38

Table 3.2 Continuing Education of Participants

Continuing Education Hours		University credits in Neuroeducation		
SLP/SLPAs	Mean	367.5	Mean	5.6
	Median	275	Median	13.5
	Range	20-900	Range	0-18
Educators	Mean	293.4	Mean	10.2
	Median	132	Median	12
	Range	75-900	Range	0-15

Table 3.3 Participants' work settings at time of study

		<u>Current Workplace</u>		
		Private Practice	Public Schools	Retired
SLP/SLPAs	1	4		3
Educators	2	3		0

Instrumentation

Semi-structured interviews were used with all participants. See Appendix A for Interview Schedules. A pilot interview was conducted with a Speech-Language Pathologist who was not part of the sample selection. Feedback from the pilot interview indicated that the interview questions elicited the desired data and no revisions were made.

Interview Questions were selected in relation to the research literature.

Questions one through six provided demographic information and questions seven and eight established that the interview participants' experience was relevant to the stated purpose of this study. The following table aligns questions 9-14 with their basis in the literature. In the case of educators, the term "speech sound disorders" was substituted for the term "sCAS" because differential diagnosis between speech sound disorders and suspected Childhood Apraxia of Speech is not part of the scope of practice for educators; but, it was assumed that all educator participants would be able to recognize a speech sound disorder. See Appendix A for schedule of educator interview questions.

Figure 3.1 Rationale for Selection of Interview Questions

Interview Question(s)	Literature Review	Rationale for Selection
9. Could you please describe, in as much detail as possible, your understanding of this neuroeducation way of intervening with a child with suspected childhood apraxia of speech?	Language structures (phonology) represent the deep structure, which is semantic. (Arwood, 1983; Chomsky, 1969; Lenneberg, 1969) Phonology is feature based (ASHA, 2007 ¹ ; Jakobson & Halle, 1971; LaRiviere, Winitz,	This question established a) whether the interview participant used a semantic basis for intervention and b) if the interview participant used overlapping semantic features

9a. Follow up Question:	Reeds, Herriman, 1974; Yoss &	
What philosophy	Darley, 1974)	
underlies your		
approach to sCAS?	Phonological repair requires	
9b. Probe Question: Some	overlapping features	
people approach	(Arwood, 2011; Costello, 1975;	
treatment with a	Hodson, 2011; Williams, 2012)	
behavioral		
modification,	Most thinkers use visual features	
language-based,	such as writing, drawing and	
combination or other	seeing print	
treatment orientation.	(Arwood, 2011; Stevenson et al.,	
What orientation did	2011)	
you use to approach		
treatment?		
For the next several	Definitions of sCAS include:	This question established
questions, I want you to	Articulatory slowness	whether the child being
think specifically about a	(Browman & Goldstein, 1989;	described likely had sCAS,
child you have worked	Weismer, et al., 1995;	according to the definitions of
with or are currently	Weismer et. al, 1995)	sCAS found in the literature
working with that presents	Abnormal scaling of articulatory	
with sCAS. Choose one	gestures	

student whose case you recall most clearly.	(Browman & Goldstein, 1989; Weismer, et al., 1995; Weismer et. al, 1995)
What characteristics led you to a diagnosis of sCAS?	Variability of speech production/segmentalization (Weismer et al., 1995) slow diadochokinesis (Yoss & Darley, 1974) omissions, revisions, additions in productions (Yoss & Darley, 1974) feature errors (phoneme prolongations, repetitions & distortions) (Yoss & Darley, 1974) absence of neuromuscular deficits (reflex, tone) (ASHA, 2007 ¹) errors in speech sound production (ASHA, 2007 ¹) errors in prosody (ASHA, 2007 ¹)

<p>Thinking of this specific child, please describe, in as much detail as possible, the course of treatment.</p>		<p>This question established the connection between the underlying philosophy and associated methods identified in question 9 and the outcomes associated with an individual case in question 12.</p>
<p>What changes did you see in the child as a result of treatment?</p>	<p>Acquisition of concepts (semantic intervention) precedes verbal speech.</p>	<p>If speech is furthered by concept development and speech is representative of</p>
<p>12a. Follow up Question: Describe the changes in language function.</p>	<p>(Chapman, 2009; Lenneberg, 1962; Vygotsky, 1962)</p>	<p>concept development, then in a semantically based intervention, there would not</p>
<p>12b. Follow up Question: Describe the changes in intelligibility.</p>	<p>Verbal speech represents concept development (Arwood, 1983; Lenneberg, 1969; Vygotsky, 1962)</p>	<p>only be changes in concepts which could be measured in language function but also changes in speech which could be measured in intelligibility.</p>
<p>13. Is there anything else you would like to share about the use of</p>		<p>This question serve the purpose of drawing out any additional information the</p>

language based intervention for speech sound disorders or for sCAS in particular?		participant wishes to share that may support their philosophy or interventions but was not addressed by other questions on the interview schedule.
14. Do you have any lesson plans or artifacts from treatment of children with sCAS that you be willing to share?	Language structures (phonology) represent the deep structure, which is semantic. (Arwood, 1983; Chomsky, 1969; Lenneberg, 1969)	This question addressed the semantic basis of intervention and quantifies the methods used with the identified approach.
14a. Follow up Question: Walk me through a lesson plan for a child with sCAS.	Most thinkers use visual features such as writing, drawing and seeing print (Arwood, 2011; Stevenson et al., 2011)	

Data Collection Procedures

Interviews were conducted in-person or by phone or Skype and audio recorded using an iPad tablet device version 7.1.2 with iOS 8.3 operating software. Interviews were then downloaded into .mov or .mp3 format on a password protected computer

and played back while the researcher spoke the words into the computer's microphone using Dragon Dictate software version 4.0.7. The transcriptions were saved in a Microsoft Word document. Following the verbal transcription, the researcher listened to the playback of the audio recording again and manually corrected transcription errors. All interviews were recorded verbatim. Feedback sound such as "um," "oh" and "ah" were omitted.

For interview participants who reported that they did have artifacts that they were willing to share, the age or grade level and gender of the subject was identified during the interview and copies were made of the artifacts without personal identifiers.

Data Analysis

The data analysis employed an overall inductive and comparative analysis strategy with the data having been coded and sorted into mutually exclusive categories to answer the research questions. Upon completion of interview transcription, all 13 transcripts were loaded into NVivo for Mac software version 11.0.0 on a password protected computer. Three passes were made at coding by theme within NVivo. The first pass resulted in each transcript being coded into a separate node by the questions asked. Follow up questions were included with the primary numbered questions. See Table 1, Appendix B for list of themes. On the second pass, the researcher analyzed each node into subnodes. See Table 2, Appendix B for list of themes. On the third pass the researcher combined data from nodes labeled Q1 and Q5 and refined the themes. See Table 3, Appendix B for list of themes.

Next, the researcher clustered questions nine, ten and eleven to assess the internal validity of participants' responses, specifically whether their definitions of sCAS and speech sound disorders aligned with their philosophy and treatment of sCAS and speech sound disorders. The researcher taped six sheets of 20# white all purpose paper together in a 3x2 grid to make one large writing surface. Then, using a triangle with two inch sides cut from cardstock, the researcher traced thirteen triangles onto the paper and labeled the three corners of each triangle "A", "P" and "I" to indicate the participant's definition of apraxia, philosophy and intervention methods respectively. The researcher then paraphrased each participant's response, including direct quotes, in separate colors of ink. Following this step, the researcher used a fourth ink color to draw lines connecting aspects of each interviewee's response that demonstrated alignment. Fully aligned clustered responses resulted in a larger triangle encompassing the two inch triangle. Finally, the researcher used a fifth ink color to draw lines among participants' responses that demonstrated themes among respondents, resulting in a flowchart representing participants' spoken beliefs about the definition of sCAS and speech sound disorders, their underlying philosophy, and intervention methods with these populations.

Answers to demographic questions one through six were typed into excel and stored on a secure, password-protected computer. Each participant was assigned a numerical value, one through sixteen, used to report any attributes or quotations attributed directly to that participant. The custom sort tool in Excel was then used to

arrange the data in order to determine the mean, median and range values reported in Chapter 4.

Member checks were performed and the completed transcript of each interview was emailed to the participants with the question “Do you see anything that doesn’t match with what you intended to say.” Responses were received from ten of 13 participants with six agreeing that the transcript representing what they intended to say. Additionally, one participant indicated that her intention was to name the Neurosemantic Language Learning Theory as her underlying philosophy (question 9a) and one participant added material to her transcript in writing. The revised material was subsequently incorporated into the coding and themes. One respondent asked to have sections of her transcript removed from analysis; they were not sections that had been included in the data analysis because they contained stories from the interviewee’s professional work that did not address the interview questions.

Four interview participants submitted multiple artifacts which contained student work. One or more artifacts was selected from each batch submitted by three of the participants. No artifacts were selected from the fourth batch because there was no evidence of refinement or change across time for a single student. The selected artifacts were analyzed in terms of the errors evident in the student work and what those errors mean through the lens of the NLLT and the refinement evident in the student work. See Chapter Four for results.

Validity and Reliability

In this research, study validity and reliability were strengthened through the use of multiple methods including interviews, member checks, an audit trail detailed herein, and analysis of student artifacts. Additionally, multiple theories were presented in the literature review, converging at the end on the Neuro-Semantic Language Learning Theory (NLLT) which embodies or is consistent with the assertions of the other theories put forth.

Researcher Bias and Limitations

While qualitative research can be increasingly valid because there is no instrument standing between the researcher and subject, they can also be subject to threat because of the inherent biases of the researcher-as-instrument. This researcher's biases are as follows: First, this researcher was and continues to be a licensed and certified Speech-Language Pathologist; and as such, this researcher approached the problem of treatment in sCAS from the perspective of an SLP but does not have any formal medical training in diagnosing motor speech disorders. Moreover, due to this researcher's ongoing continuing education investment in APRICOT™ workshops, this researcher held a personal belief that language is the vehicle by which all speech behavior can be influenced and changed. This researcher also harbors a strong distaste for traditional speech sound therapy based on the principles of behaviorism and was therefore invested in the outcome of this research to show that a language-based intervention is plausible for remediation of speech sound disorders such as those seen in sCAS. Furthermore, this researcher has taken extensive doctoral level coursework

and continuing education workshops from Dr. Ellyn Arwood, author of the Neurosemantic Language Learning Theory (NLLT), cited in this dissertation. These biases could lead to a tendency to see significance where an unbiased observer might not. These limitations were addressed through supervision from the researcher's dissertation chairperson, Dr. Ellyn Arwood, who has more than 45 years of experience, in the field of Speech Language Pathology; as well as through the use of member checks and alignment of student artifacts with results from interview analyses.

Participant Risk

There were no anticipated social, psychological or economic risks. No risk of criminal, civil liability or damage to financial standing, employability or reputation were anticipated. There may have been other risks that could not be predicted. However, this study received approval by the University of Portland's Institutional Review Board (IRB00006544) on April 17, 2015 and satisfied all IRB-related issues involving human subjects research.

Participant Safeguards

The following steps were taken to keep information about participants confidential, and to protect it from unauthorized disclosure, tampering, or damage: All data, including audio recordings, transcriptions, and artifacts were kept confidential in a secure location for three years following the study, after which time they were marked to be destroyed. Electronic copies of the data were kept on a password-protected computer accessed only by the principle investigator during the

study and were marked to be deleted from the computer three years after the conclusion of the study. The data were disseminated in writing using a numerical coding system to keep identifiable information, such as participants' names, confidential. Geographical information was reported in terms of school affiliation type (urban, suburban, rural) and region (Northwest). Additionally, the research study was reviewed and approved by the University of Portland Institutional Review Board (IRB) prior to beginning the research. IRB approval was received in April 17, 2015. All research participants were notified in writing that their participation was voluntary and that they could stop participation at any time without harm. They were also asked to sign written consent prior to participation in the study.

Summary

This chapter detailed the qualitative research design, population, participant selection, and instrumentation including a table correlating interview questions with the literature presented in Chapter Two. Methods of data analysis and measures taken to promote validity and reliability were discussed. Chapter Four details the results of this study including the triangulation of literature, answers to the research questions, themes that emerged from interview data analysis and analysis of artifacts.

Chapter Four: Results

The previous chapter described the methods used in this study. There were three components to the study: First, a triangulation of literature in the fields of cognitive psychology, neuroscience and language was undertaken to see if they propose a semantic basis to intervention in sCAS. The literature was reported in chapter two and the triangulation is reported in this chapter. Second, this literature was used to generate interview questions about what a language-based intervention for sCAS founded on principles of neuroscience, language function, and cognitive psychology, and referred to as NLLT would look like. The interviews were supported with analysis of intervention artifacts. Results from analysis of themes in the interviews and artifact analysis are found in this chapter. Last, the question was asked whether the educators and SLPs reported a semantic basis to their intervention based on the outcome of the triangulation of literature. The triangulation of literature will be reported first, followed by answering the research questions. Finally, a review of additional themes pertinent to the study will be undertaken, along with results of the artifact analyses.

Triangulation of Literature

The purpose of bringing together the literature in the fields of cognitive psychology, neuroscience and language is to create a new lens, based on neuroeducation, from which to view sCAS and to see if this new lens suggests a semantic basis to intervention. The triangulation of literature in the fields of cognitive psychology, neuroscience and language to suggest a new way of looking at sCAS is an

outcome of the literature review presented in chapter two. This section brings together relevant literature in each of the contributing fields to suggest a paradigm shift from literature that suggests that sCAS is mostly viewed as a problem with surface structures of language to considering sCAS as a disorder of language function with a semantic basis.

However, literature suggests that such surface problems as phonology and morphophonemic problems indicate a problem in the deep, semantic structure of language. First, literature in cognitive psychology reveals that all development, including speech development is a product of learning (Vygotsky, 1962), so errors in speech development will point toward the type of input that the child's learning system does not process well. That a speech act represents a child's learning up to the time of the act is also supported by Lenneberg (1969) and Peirce (1894). Second, phonological representations have been shown to be representative of underlying concepts (Claessen & Leitao, 2012; Eulitz & Lahiri, 2004). Therefore the speech sound errors seen in sCAS represent problems in the acquisition of deep structures or concepts. These deep structures are semantic in nature.

Arwood's Neurosemantic Language Learning Theory (NLLT) which was shown at the end of Chapter Two to align with the literature presented there, suggests that concepts are acquired through overlapping sensory patterns. Either auditory or visual patterns can be overlapped to form concepts (Arwood, 2009) but not all learners are able to integrate auditory patterns (Stevenson et al., 2011). Learners with speech sound disorders are especially at risk for not being able to form auditory perceptions

or representations (Stevenson et al., 2011; Yoss and Darley, 1974). In these cases, visual patterns are needed for conceptual learning.

The patterns that the visual system process are semantic in nature. Specifically, the eyes receive the properties of the light wave as a light source such as the sun or a lamp heats the air causing photons to spin off land on the edges of objects, which are reflected, back to the eyes. These properties are light and movement (Arwood, 2011; Baars & Gage, 2010). As the eyes receive the input and convert the signals to electrical impulses passed up through the brain stem, the semantic features, \pm light, \pm movement are stored in the areas of the brain corresponding to the eyes (Caramazza & Mahon, 2003), namely the visual cortex. This is also supported by the semantic representation theory, which postulates that the same neural systems used in perception and action are recruited for processing and storing semantic information (Vigliocco et al., 2009).

Thus far the literature has shown that the surface structure errors in sCAS indicate a problem with acquisition of deep structures and that people with sCAS have a visual way of learning. Two questions remain to be addressed. First, if a breakdown in the acquisition of deep structures or concepts is at the root of sCAS, how should it be addressed? Second, are there any intervention methods that access the semantic acquisition of the visual learning system?

While current methods of language-based treatment in sCAS often rely on theories of lexical processing which use the word as the unit of analysis (Pinnow & Connine, 2014), Vygotsky asserts that the word meaning, or concept, is the smallest

part of language than can be isolated (1962). Using the concept as the focus on intervention in sCAS, the interventionist can focus on agent-action-object relationships which underlie all language grammars (Bruner, 1975; Fillmore, 1977). Arwood suggests that intervention can be accomplished using event-based pictures in which contain multiple agent-action-object relationships (2011). The focus of intervention is to work off of what the child produces in order to increase the child's language function so that the child can expand, extend, and modulate those basic relationships into higher conceptual levels of representation.

Literature in neuroscience helps to answer the second question regarding how an intervention can be aligned with the visual learning systems of a children with sCAS, whose brains do not integrate acoustic and visual information to form auditory perceptions (Stevenson et al, 2011). Research suggests there is evidence for a central mechanism that crosses domains for motor movement for both the hand and buccolaryngeal movement for speech (Leighton & Heyes , 2010; Meister et al., 2003; Peters, 2012). Broca's area, situated in the temporal lobe of the brain and highly implicated in verbal speech, has as its fundamental capacity the ability to match observation and movement (Arbib & Rizzolatti, 1996). It contains mirror neurons that represent hand movements as well as verbal speech (Meister et al., 2003). This is further evidence for the connection between movement of the hand and verbal speech. Thus the triangulation of literature demonstrates that if semantic intervention, which uses movement of the hand to access language through drawing and writing concepts and their associated grapheme patterns can increase the firing potential of neurons

involved in speech production, then consideration for the individual characteristics of each sound and sound combination can be substituted for the semantic condition of the Event to promote fluent verbal speech in populations with sCAS. In summary, the literature supports both research questions. The interviews were designed to answer these questions.

Interview Results

Question 1: Will Speech Language Pathologists (SLPs) and educators with a theoretical background in the NLLT; and, who report using methods based on neuroeducation with their clients with sCAS or speech sound disorders respectively, also report positive client outcomes for both speech intelligibility and language function?

One hundred percent of SLPs and educators who reported using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively reported positive client outcomes for both speech intelligibility and language function. Specifically, ten out of thirteen participants reported increased accuracy of speech production and intelligibility. For example subject 9, an educator reported, “He seemed to have like- he could draw the picture but then it was really hard for him to get it out. But once we started doing the writing, then he would be able to say the ideas with clarity.” Subject 11, an SLP reported, “He went from not being understood at all and not being able to communicate with words to being able to use conventional language appropriately at a concrete level.” Additional themes related to outcomes of treatment and the frequency count by source are reported in table 4.1.

Table 4.1 Treatment Outcomes Themes by Source Frequency

Theme	Frequency
Better social-emotional functioning	9
Change in developmental level	7
Improved thinking and language function	7
Improved academic performance	6
Increased speech production/verbal output	5
Improved attending skills	4
Decreased reactions to un-meaningful sensory input	2
Increased range of referents for drawing, writing or speaking	2
Decreased toe walking	1
Improved handwriting	1

Question 2: To what degree will Speech Language Pathologists (SLPs) and educators who report using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively report use of methods that align with the NLLT?

All of the SLPs and educators, included in the data analysis, reported using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively. Two specifically referenced a paradigm shift. For example, subject 1, an SLP reported, “my philosophy has changed over time. Early on in my training [it] was more of a neuro-motor dysfunction. And as I’ve learned and grown over time with Neurosemantic Language Learning Theory, we pretty much use language to mediate access to motor function. So the philosophy that I currently aspire to is using language to access function and develop structure over time.” Eleven

interviewees reported approaching intervention from a language function, rather than a language structure standpoint, whereas two participants reported that their philosophy was based both on language as a whole idea and breaking ideas down into their smallest component parts, a behaviorism theory principle.

Interview participants used a variety of names for the neuroeducation approach, which are detailed in table 4.2 by frequency of source. They also defined their underlying philosophy in terms of different attributes, which are shown in Table 4.3 by frequency of source as they relate to the Neurosemantic Language Learning Theory (NLLT).

Table 4.2 Labels for the neuroeducation approach by source frequency

Label	Frequency
NLLT	7
Pragmaticism	2
Language-based	2
Arwood's methods	1
Functional language based	1
Neuroeducational	1
Viconic Language Methods	1

Table 4.3 Attributes of the neuroeducation approach by source frequency related to NLLT

Attribute	Frequency	Relation to NLLT
Respect for individuals and their learning systems involves providing information in the way the child's neurobiological	9	The NLLT differentiates between visual and auditory neurobiological learning systems at the sensory input and pattern levels. Patters are

learning system functions to develop concepts		only overlapped into concepts when they are comprised of meaningful sensory input that matches the individual's neurobiological way of learning.
Intervene with conceptual thinking and language to improve speech production	4	Language and speech production occur at the fourth level of the NLLT, which is supported by conceptual thinking at the third level. Thinking precedes speaking (Arwood, 2011).
Language acquisition mediates access to motor function	4	The NLLT demonstrates that language is acquired rather than unfolded. People with movement access to their visual learning systems acquire language through motor access and motor movement for speech is acquired through language acquisition (Arwood, 2011).
Language reflects a person's thinking and deficits in surface structures indicate the learning needs of the child	2	At the fourth level of the NLLT, language names the concepts acquired in the third level of the NLLT; deficits in surface structure in an auditory, time based language such as English indicate that the child's learning system is not auditory because if it was he would have been able to incorporate

Viconic Language Methods	1	sound and time markers into his language (Arwood, 2011). Viconic Language Methods (VLMs) are the more than 50 methodologies associated with the NLLT (Arwood, 2011).
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Other themes. Beyond the two research questions, additional themes emerged from the transcript analysis which are discussed below.

Definitions of suspected childhood apraxia of speech (sCAS). Speech Language Pathologists were asked to define sCAS in relation to a child that they had worked with. Five SLP/SLPAs gave criteria that matched the definitions found in the literature. The most frequently reported attribute that led the SLP/SLPAs to believe a child had sCAS however is one not reported in the literature around sCAS: restricted language function. Table 4.4 details the themes by source frequency and how they relate to the literature in sCAS.

Table 4.4

Characteristics of sCAS: Themes by source frequency with correlation to literature		
Reported characteristic of sCAS	Source Frequency	Correlation in Literature
Restricted language function	4	
Inconsistent speech production	3	Variability of speech production/segmentalization (Weismer et al., 1995) errors in speech sound production

(ASHA, 2007¹).

omissions, revisions, additions in
productions

(Yoss & Darley, 1974)

Motor planning deficits evident in the 2
mouth for speech or non-speech
functions

Reported diagnosis from another provider 2

Motor planning deficits evident in other 1
parts of the body

Child does not hear or process sound 1

Child is non-verbal 1

Errors in prosody, rate, rhythm and 1
intonation

errors in prosody

(ASHA, 2007¹).

Severity of child's articulation disorder 1

errors in speech sound production
(ASHA, 2007¹).

omissions, revisions, additions in
productions

(Yoss & Darley, 1974)

Slow generalization of learned sound 1
targets across speaking environments

Intervention. When SLP/SLPAs and educators were asked how they intervene with children with sCAS or speech sound disorders, respectively, based on principles of neuroeducation; and, to recall the course of treatment for a child with sCAS or a speech sound disorder, respectively; themes emerged around assessment and intervention methods. Specifically, nine of thirteen respondents indicated that the first step in intervention was assessment. Furthermore, themes emerged around how to assess and what to assess. These themes are detailed in tables 4.5 and 4.6.

Table 4.5

Themes describing how to assess by source frequency	
Methods for Assessment	Frequency
Language sample	5
Behavior checklist such as the TEMPRO	1
During intervention, informally assess how the child responds to various types of input	1

Language sampling was the most cited method for assessment. Two participants reported that within a language sample they looked for evidence the child included information about who, what, when, where, why and how of an event. Two participants reported that they looked for information indicating the child's metacognition. One participant reported that she looked for missing concepts in the language sample and one participant reported using the language sample to assess intelligibility.

Table 4.6 What to assess by source frequency

What to Assess	Frequency
How the child learns	7
The child's level of language functioning compared to expectations for age level	5
The child's level of academic functioning compared to expectations for grade level	2
The child's level of social functioning expectations for age level	2
The child's level of cognitive functioning expectations for age level	2

Within the intervention category, writing and drawing was reported on as the primary intervention strategy by 10 of 13 participants. Themes emerged within the category of writing and drawing as to specific methods, reasons to use writing and drawing, and intervention principles. These themes are detailed in table 4.7, 4.8 and 4.9 by source frequency.

Table 4.7

Methods of writing and drawing by source frequency

Methods of writing and drawing	Source Frequency
Hand over hand facilitation	7
Written labels to tag a drawing	7
Use of a picture dictionary	5
Bubbling around writing to create one idea or shape	2
Drawing in thought bubbles	2

Table 4.8

Reasons to use writing and drawing by source frequency

Reasons to use writing and drawing	Source Frequency
To refine thinking	11
To build concepts and extend language	8
To give a child context or meaning; to translate their environment visually	5
To provide visual feedback for a child's speech production	5
To use a conventional form of communication	2
To use a constant representation that does not move through space	1
Draw to write, write to read, read to speak	1

Table 4.9

Intervention Principles by source frequency

Intervention Principles	Source Frequency
Use of context	8
Working on language or concept intervention	7
Working off of the learner	7
Learning is a process; intervention methods are not a scripted program	6
Overlapping visual shapes of ideas and layering events	6
Writing and drawing at the child's level of functioning	5

The use of context was variously defined as: use of an event based picture (9 sources); use of an event, setting or shared referent (7 sources); use of academic content (2 sources); use of rich language including who, what, where, why, why and how (1 source).

Semantic basis of intervention. Based on the triangulation of literature, themes that might be expected to emerge from the interviews to support the semantic basis of SLPs' and educators' reported interventions include: use of event to support language context (Arwood, 2011; Bruner, 1975; Fillmore, 1977); use of visual patterns for intervention (Arwood, 2007; Baars & Gage, 2010; Stevenson et al., 2011; Yoss and Darley, 1974); focus on language function or conceptual thinking (Chapman, 2000; Dore, 1979; Lenneberg, 1969; Vygotsky, 1962); use of on agent-action-object relationships (Bruner, 1975; Fillmore, 1977); use of the hand for drawing and writing to promote fluent verbal speech (Arwood, 2011; Leighton and Heyes, 2010; Meister et al., 2003; Peters, 2012). One hundred percent of the 13 interviewees, whose transcripts were included in the data analysis, identified a semantic basis to their intervention.

Clustered data. Questions 9, 10 and 11 in the interview schedule addressed subjects' definitions of apraxia (for SLP/SLPAs; educators described why they believed a child they worked with had a speech sound disorder), philosophy and intervention methods. These answers were clustered for analysis. Agreement among all three responses was evident in the responses of six participants. Five of the six participants' responses triangulated around the NLLT. The sixth had dual responses

which each triangulated around traditional methods of speech therapy and the NLLT, indicating the participant moved back and forth between two paradigms. This individual did not submit child artifacts so the question of whether or not their intervention led to change in the child remains unanswered. The remaining seven participants' responses indicated agreement between their intervention methods and philosophy but not definitions of sCAS or speech sound disorders. In these cases, their definitions of sCAS or speech sound disorders centered on surface structures while their philosophy and interventions centered on deep structures and language-based interventions.

Referral. Aside from the anticipated small sample size of SLPs, one of the reasons for including educators in the interview data was that it was believed by the researcher's advisor that some educators would report not referring to an SLP. Two educators working in public schools reported that they did not refer students with speech sound disorders to SLPs because all of the students they served in that population had already been referred. One educator working in a public school reported that she did make a referral to an SLP through her building's referral process based on speech sound disorders and language functioning, and that the reason for her referral was that after the child left her classroom the following year she anticipated he would not have any support in the use of his visual learning system. She reported that his speech "did clear up significantly by the end of the year" and that his language function changed from solid sensorimotor to solidly preoperational, with occasional temporary movement into the concrete level of development academically and

socially. Two educators in private practice reported that they did not refer children to SLPs for speech sound disorders.

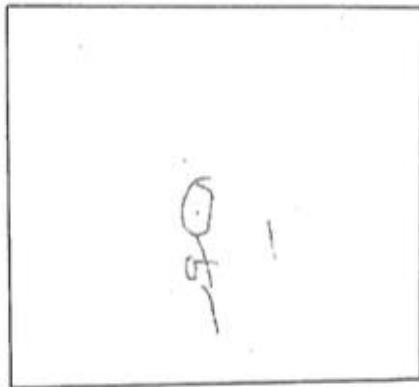
Summary of interview results. The two research questions dealing with whether the target populations would report positive client outcomes as a result of language-based intervention strategies and whether they would also report using methods based on principles of neuroeducation in intervention with children with sCAS or speech sound disorders were both answered in the affirmative. Additional themes were found around definitions of sCAS, intervention methods and alignment of diagnostic criterion, philosophy and intervention methods among interviewees.

Artifact Analysis: Subject One

Subject one was an 18 year-old student a suburban high school in the Pacific Northwest. The artifacts were submitted by the subject's special education teacher.

Figure 4.1 Subject 1, Artifact 1

Jan. 2014 and Dec. 2014



mondy
 4 schooldags
 no schooldags
 mondy
 4 schooldags
 mondy
 4 schooldags
 schooldags



ryan and mike will
 play the sorry
 game
 at the
 mike's
 house during
 the summer.

Left side of artifact:	Right side of artifact without adult refinement:	Right side of artifact with adult refinement:
“Mondy	“ryan mike	“ryan and mike will play
4 schooldags	played house	the sorry game at mike’s
no schooldags	sorry	house during the

4 schooldags	game	summer.”
mondy	at	
4 schooldags	mike	
schoold ags”	house	
	summer”	

The left side of artifact one represents the student’s thinking in January 2014, at age 18 and the right side represents the student’s thinking in December 2014, twelve months later at age 19. Below the artifact are transcriptions of the writing as it appears with the original capitalization, punctuation and spelling.

January 2014. The, January 2014, artifact demonstrates that the student is thinking at an early preoperational level because he is the only person in his picture (Arwood, 2011). Moreover, the person represented in the picture lacks agency. He is not performing an action in relation to any objects or other agents, nor does the pictorial representation contain the elements of agency such as facial parts, complete arms and legs. Like the drawing, the writing is pattern-based. The student mixes numbers and letters, makes spelling errors based on an attempt to use a sound-based system that does not function for him, and lacks connections among ideas.

December 2014. In the December 2014 artifact, the student demonstrates higher preoperational thinking. There are two agents represented in the drawing, although they are not facing one another, which indicates that the student is not thinking about other people as agents, at a concrete level of thinking. He may be

seeing other people around him as objects. The student has labeled both people in the picture. All of the ideas in his writing are spelled conventionally and spaces appear between words rather than among words, indicating that the student used a visual-motor approach to writing his ideas aligned with his learning system, rather than a sound-based approach. The student's writing reflects that he does not use time, as the elements of English that mark time such as "during," "the," "and," and "will" were absent from his writing.

The use of space in the student's writing, with most of the ideas written down the center of the page, indicate the student's body parameters, which means that that the student was on the page when he wrote these ideas, indicating a preoperational level of development.

December 2014 with adult refinement. The purpose of the adult's refinement was to provide additional meaning in the way that the student learns in order to refine the student's thinking. This process of refinement is supported by the supposition that learning is a socially mediated process (Vygotsky, 1962) and conceptual learning requires scaffolding by an experienced other (Coltman et al., 2002; Vygotsky, 1962). The adult added motion to the agents' bodies using lines to indicate walking, arrows to indicate directionality, and bent limbs to indicate action. Additionally, the adult added thought bubbles, which contain pictures, to the student's drawing to increase the thinking from a preoperational to a concrete level by thinking about the other agents involved in the event. Finally, the adult tagged the student's ideas in the picture that had not yet been tagged such as "playing," "sorry," and "game." The adult then

worked with the student to cross out ideas that did not match the picture and add ideas that matched the picture, especially time elements, so that the final story read “ryan and mike will play the sorry game at mike’s house during the summer.” Because the punctuation and capitalization are missing, and the ideas did not completely match (e.g., “playing” in the picture indicates present tense, an event that is happening now and “will play” in the written story represents future tense, an event that will happen in the future), additional refinement was needed. The story needed to be processed through the student’s learning system to see what he understood following this refinement by having him draw and write about the event again.

Artifact Analysis: Subject Two

Subject Two was a nine year-old child seen by an educator in a private practice setting in the Pacific Northwest.

“Selection D” is a graded reading passage that was used as a basis for assessment and intervention with Subject Two. See appendix C for reading passage.

Figure 4.2 Subject 2, Artifact 1

6/16/14

x he jumd into wescul
 x the Redenswam into the
 x water
 x Crak of thunder,
 x wated to hid
 x A big wave wathaway into
 x the water,

Transcription of artifact 1:

“he jumd into wescu

the Redenswam into the

water

crak of thunder,

wated to hid

a big wave wathaway into

the water.”

Analysis of artifact one. This artifact from a nine year-old male was created in response to Selection D. The child’s writing demonstrates that he was using a sound based approach to spelling words, which was not compatible with his learning system, as evidenced by the misspellings (jumped, rescue, crack, wanted, wash). The child wrote the sounds that he heard, which were based on auditory misperceptions. Some of these auditory misperceptions also represent common patterns of substitution in articulated speech, as in the substitution of “w” for “r” in “rescue.”

The child does not use writing conventions such as capitalization at the beginning of a sentence. Some of his ideas run together, indicating that he is not associating each word with an individual meaning and therefore not putting space between the words. The child also used pronouns without referencing whom they refer to, which indicated preoperational thinking. He did not think about how other people reading his story would not have the same information as he did.

Figure 4.3 Subject 2, Artifact 2

6/16/14

Picture Dictionary for Selection D









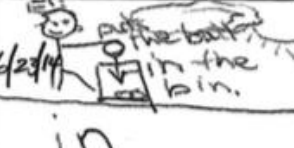


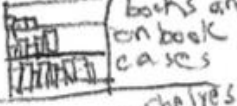




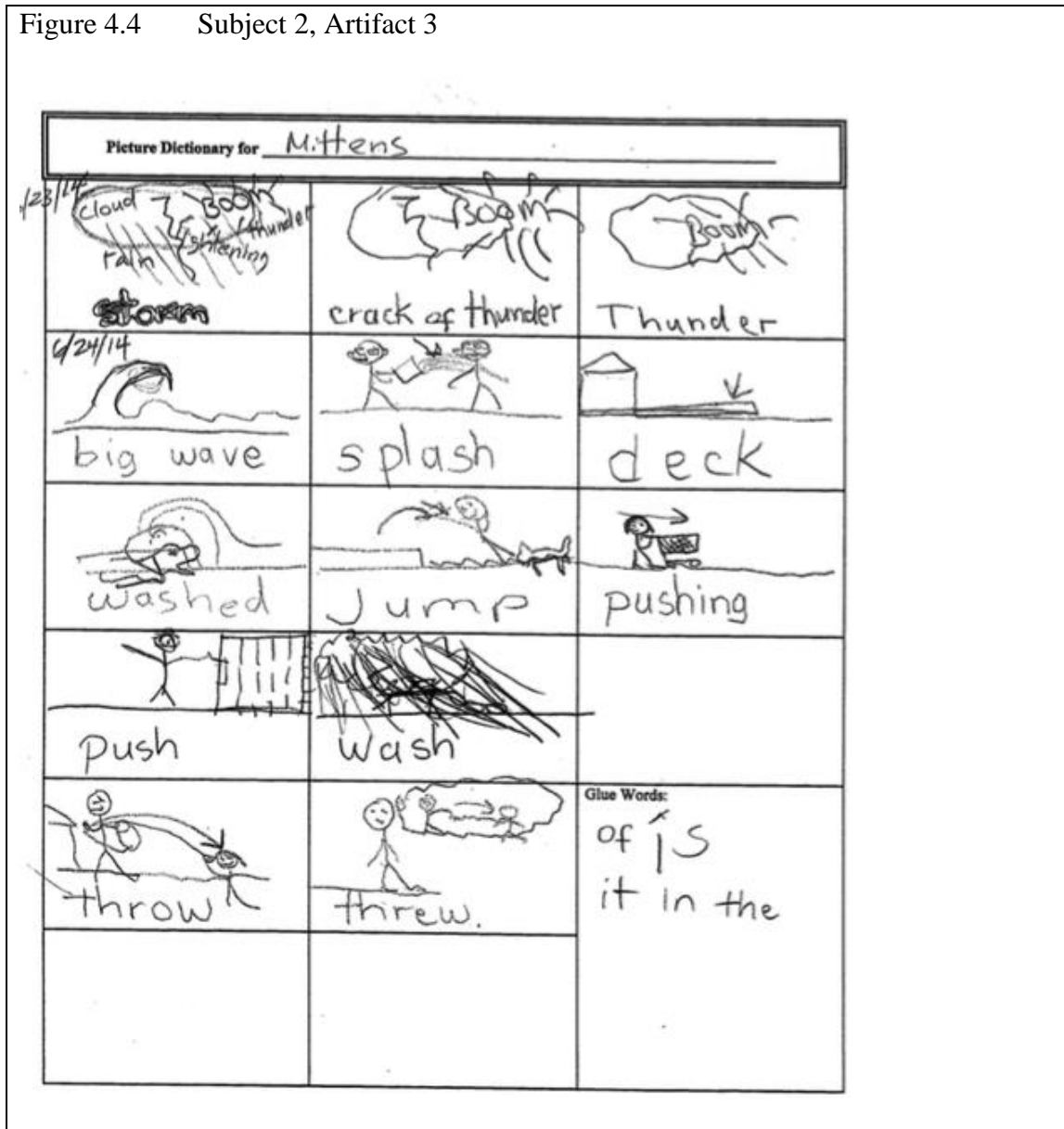
 <p>houseboat</p>	 <p>running</p>	 <p>staying</p>
 <p>inside</p>	 <p>rough weather</p>	 <p>Mittens</p>
 <p>cabin</p>	 <p>went</p>	 <p>in</p>
 <p>out</p>	 <p>shelves</p>	 <p>book cases shelves</p>
 <p>scared</p>	 <p>because</p>	<p>Glue Words:</p>
 <p>rain</p>	 <p>lightening</p>	

Figure 4.4 Subject 2, Artifact 3



Analysis of artifacts three and four. Artifacts three and four constitute a picture dictionary for the story in Selection D completed simultaneously with artifact five as a tool for indexing and refining ideas. Each frame in the picture dictionary

contains a single idea with a clearly printed written pattern in conventional English and one or more drawings that illustrate the idea. Arrows indicate relationships. The picture dictionary contains significant ideas in the story, Selection D.

Figure 4.5 Subject 2, Artifact 5

		<p>6/23/14 MOTHERS out of the house because she is glare of the house</p>
		<p>6/23/14 MOTHERS out of the house because she is glare of the house</p>
		<p>6/24/14 MOTHERS out of the house because she is glare of the house</p>
		<p>6/24/14 MOTHERS out of the house because she is glare of the house</p>

	Transcription of Artifact before adult refinement	Transcription of artifact with adult refinement
Frame 1	“Mimtis the cat is going into the caben and Patty whet inside wheth her.”	“Patty is running into the houseboat.”
Frame 2	“Patty ran in the house boat becase she is scared the crack of thud.”	“Mittens the cat went into the cabin and Patty went inside with her.”
Frame 3	“She runnin into the hoaboat Patty staing insid fome Patty hoseboat and wheninto the cabin”	“Mittens ran out of the house boat because she is scared of the crack of thunder.”
Frame 4	“Mittens ran back insid the house boat.”	
Frame 5	“A big wave in the water pheling mittns back into the water”	“A big wave in the water pushed Mittns into the water.”
Frame 6	“Dad tro the rope to Patty”	“Dad threw the rope to Patty.”

Analysis of artifact five. The child's writing before refinement indicates that he continued to make the same mistakes evident in the artifact two, namely misspellings and use of pronouns without first referencing a person. However, the child's drawing, which is done prior to writing, indicates that the use of a visual medium for thinking is aligned with his learning system because his ideas are more expanded in artifact five than in artifact two. Compare the idea "crak of thunder", which is a fragment, in artifact two with the expanded idea "Patty ran in the house boat because she is scared of the qrak of thud" in artifact five. The latter idea employs an agent (Patty), an action (ran), an object (houseboat), is modulated (the idea "ran" is conjugated from the verb "to run") and contains a semiosis ("because she is scared") for the action. This demonstrated that when drawing his ideas, which represent his thinking, the child was able to use language at a level commensurate with his thinking. This supports the idea that the child has a visual learning system.

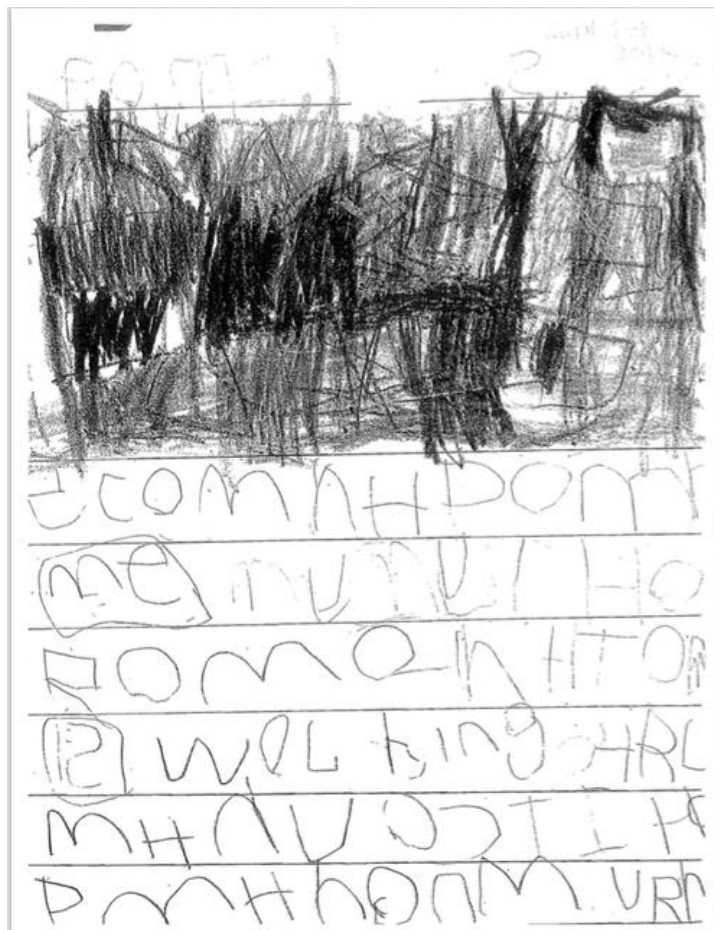
The child changed word spellings between artifacts two and five such as "crak" in artifact two and "qrak" in artifact five, indicating that he was relying on an auditory, sound-based way of writing which did not match his learning system. However after the idea "Mittens" was put into the picture dictionary on 6-16-14, the child used the conventional spelling of "Mittens" to label or tag the idea in his drawing on 6-23-14 and in his writing on frame 4 on 6-24-14, indicating that the child was able to use the visual shape of the idea paired with a pictograph of its meaning to write an idea consistently over time.

The adult refinement consisted of indexing ideas into the picture dictionary to support the child's thinking about the meaning of each idea, adding to and tagging ideas in the cartooned pictures in each frame so that they each contained an agent, action and object, and refining the child's written patterns so that they matched the pictures. All of this was done to increase and refine the child's thinking.

Artifact Analysis: Subject Three

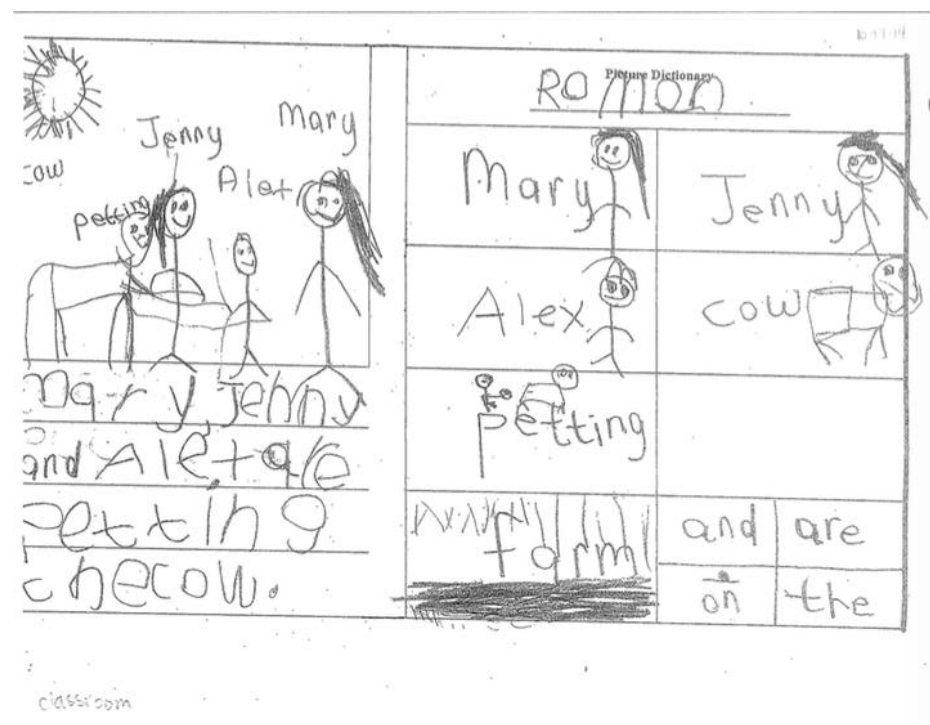
Subject Three was a five year-old student at a suburban elementary school in the Pacific Northwest. Artifacts were submitted by his speech-language pathologist.

Figure 4.6 Subject 3, Artifact 1



Analysis of Artifact One. This artifact demonstrates the child's ability to represent his concepts with language, in September 2013, at age five. There are no agents, actions or objects in the picture. There are three ideas in the writing, "me", "Romen" and "is" with the "s" written backward in the latter idea; these labels list semantic relationships for agent, action and object. The remainder of the writing was made up of mixed uppercase and lower case letters and constituted patterns that had not been refined into concepts.

Figure 4.7 Subject 3, Artifact 2



Transcription of the artifact

“Mary, Jenny and Alex are petting thecow.”

Analysis of Artifact Two. Artifact two, a student work sample created approximately one year after artifact one on October 17, 2014 at age six, represents the student's thinking about an event-based picture taken from his classroom content. See Appendix E for the artifact, which contains the event-based picture with labels.

In this artifact, the student drew ideas to represent his thinking. The ideas were then tagged in the picture through adult refinement and put into the picture dictionary on the right side of the artifact to index them. The student then drew pictures of each idea in the picture dictionary. Following this, he was able to write the sentence "Mary, Jenny and Alex are petting the cow." Each word is spelled conventionally. Errors in spacing such as the lack of space between the ideas "the" and "cow" indicate that the student does not have a mental representation for the idea "the" and is therefore unable to separate the idea "the" from "cow." The student's refinement is also visible in the extended arms of the people in the drawing which demonstrate that after drawing three people standing face-forward on the page, the student was able to recognize through adult refinement of this thinking, that the idea "petting" implied that people's hands were in contact with the cow.

This artifact demonstrates that use of visual-motor strategies such as drawing before writing and indexing ideas in a picture dictionary, which allow the student to access his concepts that align with his learning system. It demonstrates a raise in thinking from artifact one because it includes people acting in relationship to an object whereas the artifact one did not include any concepts.

Summary of artifact results. Artifacts of student work were analyzed for three students between the ages of five and 18. Each artifact demonstrated restricted language function and orthography as marked by incomplete agent-action-object relationships and written speech acts that were not expanded, extended and modulated in time (Arwood, 2011; Bruner, 1975; Fillmore, 1977). Each artifact also revealed the process of adult refinement through the learner's system (Arwood, 2011; Vygotsky, 1962) and the resultant gains in language function and orthography were noted. Chapter Five contains a discussion of the relationship between language function, orthography and phonology. The impaired phonological system and subsequent impairment in intelligibility are inferred as are resultant gains in speech intelligibility.

Summary

Both of the research questions were answered in the affirmative. SLP/SLPAs and educators who report using a neuroeducation approach to intervention with sCAS or speech sound disorders respectively reported positive student outcomes for both intelligibility and language function. Additionally, the interview participants reported a paradigm shift to the use of a language function-based intervention. The various names for the neuroeducation paradigm shift were listed and the clustered analysis of participants' alignments in diagnosis, philosophy, and intervention were reported. Artifacts from three students who presented with sCAS or speech sound disorder and, who received intervention based on the principles of language function, as reported in this chapter were analyzed. A discussion of the significance of these findings follows in Chapter Five.

Chapter Five: Conclusions and Discussion

Introduction

Chapter Four presented the results of the study including analyses of both interview data and child artifacts. This chapter includes a discussion of those results. A brief summary of the study is given followed by a discussion of how the results in this study compare to those of previous studies and also highlights significant findings. The limitations of this study are discussed, as well as suggested directions for future research. The penultimate section discusses transferability of the findings and is followed by a summary section.

Overview of Study

This study was comprised of several components. First, a literature review presented findings in the fields of cognitive psychology, neuroscience, and language that demonstrated a gap the literature between considering suspected Childhood Apraxia of Speech (sCAS) as a speech disorder even though ASHA definitions of speech and language identify sCAS as both a speech (ASHA, 2007⁴) and a language disorder (ASHA, 2007⁵). Furthermore, current interventions focus on speech and language forms (Costello, 1975; Hodson, 2011; Pinnow & Connine, 2014; Storkel & Morrisette, 2002; Williams, 2012). This study also showed that these three fields can be aligned to form a new lens called neuroeducation and that the Neurosemantic Language Learning Theory (NLLT) aligns with the new lens, and can serve as a basis to intervention. Interviews were conducted with Speech-Language Pathologists (SLPs) and educators who reported using methods based on the tenets of the NLLT to

uncover the specific methods used and outcomes they had with children with sCAS and speech sound disorders respectively. Their answers and selected artifacts provided by three of the participants were analyzed. It was found that both SLPs and educators who use methods of assessment and intervention based on the NLLT reported positive outcomes for intelligibility and language function. The respondents also reported using intervention methods that align with the NLLT to a high degree. Additional themes that emerged from the analysis were reported in Chapter four.

Comparison and Discussion of Results

Chapter Five, concerned with a discussion of study results, presents an opportunity to share and bring to the reader's attention those aspects of the study's results that may most significantly impact the field. The following five subsections highlight study results that support the paradigm shift from the current sound-based model to one that considers language as a whole, rooted in Pragmaticism philosophy. Findings are discussed in relation to the current literature in the field.

Focus on sounds versus language. The review of literature demonstrated that while suspected Childhood Apraxia of Speech (sCAS) has been considered as both a speech disorder and a language disorder, the resultant interventions in each case focus on remediation of sound production out of the context of meaning (Merzenich, 1996), which will result in a great deal of similarity of sound (Pinnow & Connine, 2014). It has also been shown that not all children are able to integrate the visual and acoustic properties of audiovisual speech and therefore do not experience temporal synchrony (Stevenson, et al., 2011). Such children are likely to exhibit a deficit in semanticity of

language although current literature on sCAS and speech sound disorders does not evaluate this aspect of the communication system. In the language theorists section of Chapter two, pragmaticism, a term that means the whole is greater than the parts, was introduced and it was noted that the current interventions in sCAS take a static approach, working on the products of language rather than the dynamic process of creating meaning. Pragmaticism represents a shift from a behaviorism or a reductionist paradigm that considers the smallest elements of speech for remediation to one that considers the whole of the thought, language and speech process in sCAS. The shift has broad implications for the degree to which children with sCAS and other communication disorders can be helped by intervention. Arwood notes that,

“Until the current static analysis approaches yield to more qualitative, logical analysis of the child’s total system, it is unlikely that children with serious language problems will be significantly helped. This statement is based on the fact that underlying the signs of the sign-user is cognition and features (semantics). The conventionality of the sign is a mode of experience, not the underlying thought object. Only when the “signs” are used by the sign-user as representative of the underlying thought object is communication less likely to be in error” (p. 11, 1984).

The literature review in Chapter Two noted that there is a need to consider sCAS as a disorder of language function, not just a structural, morphophonemic/motor problem. The results in Chapter Four demonstrated that eleven out of thirteen interview

participants approached intervention from a basis in language function, which had implications for how the participants approached treatment.

Contribution of restricted language function. Interestingly, the most frequently reported attribute that led the SLP/SLPAs to believe a child had sCAS is one not reported in the literature around sCAS: restricted language function. The results in chapter four revealed that subjects' definitions of apraxia (for SLP/SLPAs; educators described why they believed a child they worked with had a speech sound disorder), philosophy and intervention methods were clustered for analysis and agreement among all three responses was evident in the responses of six participants. The remaining seven participants' responses indicated agreement between their intervention methods and philosophy, but not definitions of sCAS or speech sound disorders. The findings suggest that philosophy influences intervention methods. Specifically, the results bore out the idea that philosophical beliefs about sCAS being a disorder of speech structures results in working on structures, while philosophical beliefs about sCAS being a disorder rooted in language function results in semantic intervention to increase language function with the expectation that speech intelligibility will follow. As one interviewee said "...if we can get in and help put the sensory information in the way that the child or the adult needs to have that information put in then we are going to see connections form and relationships form and we're going to see concepts form and pretty soon, the gift we will get is language coming out."

Alignment of visual- motor system and language. It was demonstrated in Chapter Two that the deficits seen in sCAS originate prior to the programming stage of speech (Arsenault & Buchsbaum, 2015); the deficit may begin at the earliest levels of processing of the temporal auditory wave when a lack of temporal synchrony is seen (Stevenson et al., 2011). Moreover, it was concluded that phonological system impairments can be overcome through increased meaningful input in the semantic area of language to provide the integration and inhibition necessary to overcome the effects of neighborhood density and word frequency that are considerations in phonological programming for speech sound production considered in isolation (Storkel & Morrisette, 2002). The conclusion that increased meaningful input was needed was also based on information set forth in the language theorists section of Chapter Two which demonstrated that the speech act or utterance act represented the child's learned development up to that point (Arwood, 1983; Chapman, 2000; Lenneberg, 1962; Vygotsky, 1962). If speech represents what the speaker understands, then the errors in speech characterized by sCAS demonstrate a lack of concept acquisition. How then is increased meaningful input provided?

Lenneberg noted that language learning actually correlates better with motor development than with chronological age (1969). Ten of thirteen interview participants reported a motor-visual approach to intervention, specifically the use of writing and drawing to increase semantic knowledge or to provide the patterns necessary for the child to acquire concepts (See Tables 4.7 and 4.8).

Literature reported in Chapter Two revealed a basis for the interventions described in the results in Chapter Four. Namely, an evolutionary or phylogenic connection between the movement of the hand for tool use and the development of human speech has been uncovered, as well as a evidence for a connection between hand movement and spoken language (Meister et al, 2003). A motor system control mechanism that transcends domains between hand and mouth has also been documented in investigational studies (Peter, 2012); and, studies of blind subjects reading Braille, which occurs through movement of the hand over raised bumps to discriminate text have indicated that the primary visual cortex is activated (Sadato et al, 1996). Myklebust and Brutten (1953) also suggested that “the motor cortex is prominently involved in the elaboration of visual sensations into perceptions” (p. 17). Although the exact mechanism(s) that underlie the facilitation of human speech through hand movement are unknown, mirror neurons are implicated in the process (Arbib & Rizzolatti, 1996; Meister et al., 2003). Significantly, one hundred percent of the interview participants reported positive client outcomes in terms of both language function and speech intelligibility for their clients based on a neuroeducation approach, which ten out of thirteen participants indicated included the use of drawing and writing, a motor-visual intervention.

Orthography, phonology and language. There is not currently any literature surrounding sCAS that describes the connection between orthography, phonology and language. While speech language samples of children with sCAS or speech sound disorders prior to and following intervention, based on a neuroeducational approach,

were not obtained in this study, a connection can be extrapolated based on the student artifacts analyzed in Chapter Four.

In Artifact One presented in Chapter Four, the 18 year-old student's first work sample indicated restricted language. The student wrote the pattern "schooldags" four times, the pattern "mondy" four times and "schoold ags" one time. If the patterns were spoken as written, the student would demonstrate a lack of word boundaries (e.g., schooldags vs. school dags) as well as phonemic errors based on the misspellings. The student's second written work sample continued to indicate restricted language although concepts had begun to emerge that matched the drawn representation of the student's thinking and were absent in the first rendering such as agent(s) doing action(s). One instance of modulation of grammar was used (e.g., "played") and objects were specified (e.g., "sorry game"). Word boundaries were observed and time elements such as "at" and "summer," and location elements such as "mike house" were included. The student's orthography and language, although still restricted, not representing a full adult grammar as would be expected at the chronological age of 18, had improved. The expected result would be that the student's intelligibility in spoken language would also have improved. This is borne out in the themes reported in Chapter Four which indicate that students' intelligibility levels did improve as a result of drawing and writing with students.

It is important to note that the drawing and writing was not part of a prescriptive program. Rather, the participants reported working off the child's own learning system (see table 4.9). Arwood substantiates this theme, noting that "...the

natural intervention procedure should emphasize the dynamic process. There is no way of predetermining a specific function—only can opportunities with appropriate models directing the speaker determine the functioning. The purpose, intent and function are dependent on the requisite semantic skills” (1984, p. 29).

The artifacts from Subject Two presented in Chapter Four were written by a nine year-old boy. His orthography in the first artifact revealed use of incomplete sentences and unreferenced pronouns, which Arwood (1984) considered to be indicators of restricted language function. He also used misspellings that indicated he was writing what he heard as he pronounced the words, based on faulty phonological representations (e.g., “jumpd/jumped, wescu/ rescue, wated/wanted, wathaway/wash away) (ASHA, 2007⁴; Claessen & Leitao, 2012).

The transcription of Subject Two’s Artifact Five in Chapter 4 indicates increasing language function. For instance he used referenced pronouns, first naming “Mimtis the cat” and “Patty” then using the pronouns “her” and “she.” Although multiple misspellings continue to be evident, it must be noted that this artifact was a working document which was refined over time. The educator who worked with Subject Two to refine his work reported “he could draw the picture but then it was really hard for him to get it out. But once we started doing the writing, then he would be able to say the ideas with clarity.” This is substantiated by the dates on the student artifacts. In Artifact Five the idea “Mittens” is misspelled in the first several frames. On June 16, 2014, Subject Two wrote and drew the idea “Mittens” in his picture dictionary (see artifact 3). On June 24, 2014, the subject wrote the idea “Mittens”

correctly in Artifact Five, demonstrating that he was able to reproduce the idea correctly orthographically after processing it through writing and drawing and based on the educator's report, also with phonological accuracy.

Subject Three's first artifact demonstrated very restricted language function in the orthography which consisted of mixed upper case and lower case letters written forward and backward without spacing. The subject's work may have been considered pre-writing, an awareness that written ideas are represented with shapes called letters, but mostly lacking awareness of specific shapes of ideas. Three ideas were found in the writing sample, "me," "Romen" and "is," with the latter idea containing a backward "s." The unrelated ideas did not form a semantic proposition and appeared to match the level of conceptual representation in the drawing which consisted of shaded patterns. At age five, the child demonstrated a restricted language function.

The second artifact, produced in response to an event-based picture, demonstrated increasing semanticity for Subject Three. The student represented agents and objects in his picture with hand location indicative of action. His written patterns used improved spacing to indicate awareness of word boundaries and all of the patterns were spelled correctly. These improvements may have been attributable to the processing of the story through his system with refinement as evidenced in the accompanying picture dictionary in Artifact Two. While a speech language sample was not available, it can be inferred based on the themes reported in Chapter Four that the child's intelligibility improved in conjunction with his orthography and language function.

Neurosemantic Language Learning Theory. As discussed in Chapter Two, the Neurosemantic Language Learning Theory (NLLT) aligns with the literature in cognitive psychology, neuroscience, and language; this suggests a paradigm shift from the consideration of sCAS as a motor-based speech sound disorder to one of language function. All of the SLP/SLPAs and educators interviewed reported using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively; and, seven participants specifically named their broadly termed neuroeducation approach as the NLLT (see table 4.2).

The NLLT is the embodiment of pragmatism philosophy. Applied to sCAS and speech sound disorders, it suggests that learning takes place on four levels. At the first level, sensory input is received and processed by the brain. The dual mechanisms of inhibition and integration allow patterns to be created from meaningful input at the second level. As has been recognized in the preceding chapters, children with sCAS and speech sound disorders have a deficit in auditory integration and therefore will require overlapping patterns of visual information in order to form patterns at the second level of the NLLT which are overlapped to form images or semantic concepts at the third level (Arwood, 2011). At the fourth level of the NLLT, language is used to name the acquired concepts (Arwood, 2011). The use of language to refine conceptual thinking was demonstrated in the artifacts presented in Chapter Four, which also resulted in improved orthography, language function and by extension, speech intelligibility, an outcome of the phonological system. Results in Chapter Four suggest that writing and drawing are effective visual-movement patterns for children with

sCAS and speech sound disorders; these patterns can be given as input at the first level of the NLLT and can result from the child's thinking at the third and fourth levels of the NLLT. The NLLT can be used as a basis for intervention with sCAS and speech sound disorders with the expected result of overall improved language function and intelligibility.

Limitations of Study

This study had a limited sample size. Interview data were collected from 16 cases with 13 included in the analysis. Only four participants provided child artifacts and three of these were used in the analysis. While the respondents did represent two related fields: education and Speech-Language Pathology, and two settings: private practice and public schools, a more robust sample size might provide additional weight to the evidence. Further limitations include that three interview participants did not respond to the member check performed and that methods reported by participants could have been skewed from what would have been observed if observations had been undertaken.

Future Research Directions

The results of clustering interview participants' answers to questions 9, 10 and 11 (see Appendix A for interview schedule) to determine if their definitions of sCAS, philosophy and intervention methods were aligned, indicated that six out of 13 participants met this criteria. Further research might examine the predictive factors that lead to an SLP or educator having made a paradigm shift from the dominant paradigm to pragmatism or use of the NLLT lens. Such factors could include hours

of education, years in practice, competence in self-reflection in their own practice, and opportunities to apply their learning. That analysis was not undertaken in this study.

An intervention study which directly compares the results of children with sCAS on factors of both speech intelligibility and language function using standard phonological remediation techniques with the control group and Viconic Language Methods™ (VLMs), based on the NLLT with the experimental group could be a direction of future research. Such a study would allow direct comparison of outcomes in a way that has not yet been published in the scientific literature because language function is typically not a pre- and post- intervention measurement.

Transferability

The first part of this study involved a triangulation of the literature in the fields of cognitive psychology, neuroscience and language to see if they would inform methods in sCAS. The result was that a new paradigm was suggested for sCAS based on a neuroeducation lens. As an outcome of neuroeducation, this finding is transferrable to the field in as much as it demonstrates a method for examining the literature from three domains rather than the traditional two, with language omitted.

The second part of this study was undertaken with SLPs and educators who self-reported use of the NLLT or associated methods, VLMs to intervene with children with sCAS or speech sound disorders respectively. All of the participants had previous exposure to the NLLT or Pragmaticism philosophy through continuing education workshops conducted by Dr. Ellyn Arwood and colleagues; some had also taken

university level courses in Neuroeducation with the same professor. The findings in this study may be relevant to professionals who work with children with sCAS or speech sound disorders who are in the process of making or have made a paradigm shift to pragmatism philosophy. The thematic results gained from interview analysis suggest that persons who have not fully made the paradigm shift may experience mixed results in intervention outcomes. Participants reported working off of the learner as a primary theme and therefore a description of the intervention methods would be insufficient for a practitioner unfamiliar with the NLLT to apply to intervention, because she or he would not have the background theory on which to base decisions of what specific method or tool to use and in what situation to use it.

Practitioners who find this study applicable to their own work may gain an understanding of the learning process underlying language and speech acquisition and how interventions based on the NLLT can guide significant learning gains for all children. Any person who works with children with speech sound disorders may find the literature review in Chapter Two helpful as it lays out the paradigm shift from the dominant model to a pragmatism lens specific to the diagnosis, assessment and remediation of speech sound disorders including sCAS.

Summary

This study sought first to explore the pertinent cognitive psychology, neuroscience, and language literature that surrounds the diagnosis and treatment of children with Suspected Childhood Apraxia of Speech (sCAS) with the intent of finding a translational neuroeducation approach to the treatment of sCAS. It then

asked the question, what do professionals who have some neuroeducation training say they do when they treat children with sCAS? Specifically, the study inquired as to whether Speech Language Pathologists (SLPs) and educators with a theoretical background in the NLLT; and, who report using methods based on neuroeducation with their clients with sCAS or speech sound disorders respectively, also report positive client outcomes for both speech intelligibility and language function, a question that was answered in the affirmative. It also asked to what degree will Speech Language Pathologists (SLPs) and educators who report using methods based on principles of neuroeducation with their clients with sCAS or speech sound disorders respectively report use of methods that align with the NLLT and found that the answer was, to a very high degree.

A literature gap was revealed in the consideration of sCAS as a disorder of language function and triangulation of the literature in the fields of neuroscience, cognitive psychology and language suggested a new way of approaching sCAS through a neuroeducation lens. The significance of this study is that it makes an application to speech sound disorders based on the NLLT and demonstrates that not only can language and speech be improved by working off the learner using a semantically-based intervention, but also that SLPs need not be the primary or sole interventionists for children with sCAS or other speech sound disorders based on the successful reported outcomes of the educators interviewed. The study provides an application in the newly emerging field of neuroeducation, which can be built upon by future researchers. It has supported a paradigm shift in this researcher who otherwise

might be on an outbound trajectory with regard to the field of Speech-Language Pathology. This researcher has learned that “drill and kill” need not be the only approach and is likely not the best approach to remediation of speech sound disorders and that by working through and with a child’s language system, speech can be improved in a way that is respectful to the learner.

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Appendix A

Interview Questions

Interview Questions for Speech Language Pathologists

1. What is your first and last name?
2. Where do you work?
3. Is this a private practice, school, or other type of treatment facility?
4. How long have you been in the field of Speech Language Pathology?
5. Are you currently licensed as an SLP and if so, in what state?
6. Do you hold a current certification with the American Speech Language Hearing Association?
7. Do you currently or have you ever served a child with suspected Childhood Apraxia of Speech (sCAS)?
8. Have you ever participated in continuing education with someone on the topic of Viconic Language Methods (VLMs), also sometimes referred to as “Arwood’s approach” or taken neuroeducation courses at the University of Portland?
 - 8a. Follow up Question: Approximately how much continuing education have you received, in hours, in these areas?

9. Could you please describe, in as much detail as possible, your understanding of the way the way this neuroeducation way of intervening with a child with suspected childhood apraxia of speech?

9a. Follow up Question: What philosophy underlies your approach to sCAS?

9b. Probe Question: Some people approach treatment with a behavioral modification, language-based, combination or other treatment orientation.

What orientation did you use to approach treatment?

For the next several questions, I want you to think specifically about a child you have worked with or are currently working with that presents with sCAS. Choose one student whose case you recall most clearly.

10. What characteristics led you to a diagnosis of sCAS?
11. Thinking of this specific child, please describe, in as much detail as possible, the course of treatment. What changes did you see in the child as a result of treatment?
12. What changes did you see in the child as a result of treatment?

12a. Follow up Question: Describe the changes in language function.

12b. Follow up Question: Describe the changes in intelligibility.

12c. Follow up Question: Please describe the child's functioning in terms of speech and language at the beginning and end of the time you worked with them?

13. Is there anything else you would like to share about the use of language based intervention for speech sound disorders or for sCAS in particular?
14. Do you have any lesson plans or artifacts from treatment of children with sCAS that you be willing to share?
 - 14a. Follow up Question: Walk me through a lesson plan for a child with sCAS.

Interview Questions for Educators

1. What is your first and last name?
2. Where do you work?
 - 2a. Follow up Question: Is this a private practice, school, or other type of treatment facility?
3. How long have you been in the field of Education?
4. Do you currently or have you ever served a child with suspected Childhood Apraxia of Speech (sCAS)?
5. Do you currently or have you ever served a child with speech sound difficulties?
6. If you did serve a child with speech sound difficulties, did you refer them to an SLP? If no, why not?
7. Have you ever participated in continuing education with someone on the topic of Viconic Language Methods (VLMs), also sometimes referred to as “Arwood’s approach” or taken neuroeducation courses at the University of Portland?

7a. Follow up Question: Approximately how much continuing education have you received, in hours, in these areas? Could you please describe, in as much detail as possible, your understanding of VLMs?

8. Could you please describe, in as much detail as possible, your understanding of the way the way this neuroeducation way of intervening with a child with speech sound difficulties?

8a. Follow up Question: What philosophy underlies your approach to working with children with speech sound difficulties?

8b. Probe Question: Some people approach treatment with a behavioral modification, language-based, combination or other treatment orientation.

What orientation did you use to approach treatment?

For the next several questions, I want you to think specifically about a child you have worked with or are currently working with that presents with speech sound difficulties.

Choose one student whose case you recall most clearly.

9. Thinking of this specific child, please describe, in as much detail as possible, the course of treatment.

10. What changes did you see in the child as a result of treatment?

10a. Follow up Question: Describe the changes in language function.

10b. Follow up Question: Describe the changes in intelligibility.

10c. Follow up Question: Please describe the child's functioning in terms of speech and language at the beginning and end of the time you worked with them?

11. Is there anything else you would like to share about the use of language based intervention for children with speech sound difficulties?
12. Do you have any lesson plans or artifacts from treatment of children with speech sound difficulties that you be willing to share?
 - 12a. Follow up Question: Walk me through a lesson plan for a child with speech sound difficulties.

Appendix B

Themes resulting from Coding in NVivo

Table 1: Themes resulting from coding by question in NVivo

Q1: Describe your approach to Intervention using Neuroeducation methods

Q2: Philosophy

Q3: name your approach

Q4: characteristics of Apraxia

Q5: Intervention with specific child

Q6: outcomes of treatment

Q7: language based intervention for sCAS or speech sound disorders

Q8: referral to an SLP

Table 2: Themes resulting from coding by theme within questions in NVivo

Q1: Describe your approach to Intervention using Neuroeducation methods

Formula

How we address sounds

Children with apraxia have movement access

Thinking

Motor access

Working off the learner

Connecting or overlapping perceptual input

Refine thinking

Language or concept intervention

Deep structure underlies surface structure

Visual learning systems

Shape of the idea

Content

Assess

Writing and drawing

Q2: Philosophy

Visual access

Right to communication

Reduce to smallest part and scaffold up

Pragmaticism

Language mediates access to motor function

Respect

Working off the learner for thinking

NLLT

Acquisition influenced function

Q3: name your approach

Social Interactionist

Behaviorism system but adds meaning

NLLT, NeuroED, Language, Pragmaticism

Q4: characteristics of Apraxia

Slow generalization

Severity of the artic

Nonverbal

Doesn't hear or process sound

Bodily motor issues

Reported diagnosis from another provider

Restricted language function

Motor planning deficits

Inconsistent speech production

Q5: Intervention with specific child

Traditional sound treatment

Collaborative planning to improve language function

Visual motor aspect of whole class instruction

Working off the child

Assess

Picture dictionary

Language intervention

Thinking and thought bubbles

Learning process not program

Hand over hand facilitation

Content

Event based picture

Refining the child's output

Drawing and writing

Q6: outcomes of treatment

Toe walking or other motoric improvements

Increased range of referents for drawing, writing or speaking

Decreased sensory reactions

Behavioral change and attending skills

Speech production or verbal output increased

Academic improvements

Improved thinking and language function

Change in developmental level

Better social-emotional functioning

Increased accuracy of speech production and intelligibility

Q7: language based intervention for sCAS or speech sound disorders

Works for all by all without need for specialists or SLPs

Need theory to know what doing, process

Morale

Language mediates motor function

Patterns or input output systems don't improve functioning

Respect

Need to understand how kids process information

Meaningful input supports sound production

Focus on language instead of sounds in isolation

Q8: referral to an SLP

No in private practice

Already referred

Table 3: Themes resulting from combining and refining strands Q1 and Q5 in NVivo

Intervention Methods

Writing and drawing

HOW or methods

Hand over hand to facilitate movement

Writing with drawing, to tag drawing

Level specific to child

Picture dictionary

Bubble writing to create one idea or shape

Use of thought bubbles

WHY

To refine thinking

To build concepts and extend language

To give student context or meaning, to translate

Visual feedback for speech production

Writing is conventional

Does not move through space, constant

Draw to write to read to speak

Assess

HOW to assess or Methods

Language sample

5W+H and spans time

metacognition

intelligibility

missing concepts

behavior checklist

how the child responds to input

WHAT to assess

How does the child learn

Level of language function

Child's academic functioning

Social functioning level

Cognitive functioning level

What is Context?

Event, setting, shared referent

Event based picture

Multiple A-A-O relationships

Academic content

Rich language 5W+H

Language or concept intervention

Working off the learner

Learning process not program

Overlap shapes (lips, drawn, written, bubble, etc.)

Anomalies

Visual motor aspect of whole class instruction

Collaborative planning to improve language function

Traditional sound treatment

Q2: Philosophy

Acquisition influenced function

NLLT

Working off the learner for thinking

Respect

Language mediates access to motor function

Pragmaticism

Reduce to smallest part and scaffold up

Right to communication

Visual access

Beliefs about SSD and Apraxia

Deep structure underlies surface structure

Children with apraxia have movement access

SSD and Apraxic kids are visual learners

Q3: name your approach

Social Interactionist

Behaviorism system but adds meaning

NLLT, NeuroED, Language, Pragmaticism

Q4: characteristics of Apraxia

Slow generalization

Severity of the artic

Nonverbal

Doesn't hear or process sound

Bodily motor issues

Reported diagnosis from another provider

Restricted language function

Motor planning deficits

Inconsistent speech production

Q6: outcomes of treatment

Toe walking or other motoric improvements

Increased range of referents for drawing, writing or speaking

Decreased sensory reactions

Behavioral change and attending skills

Speech production or verbal output increased

Academic improvements

Improved thinking and language function

Change in developmental level

Better social-emotional functioning

Increased accuracy of speech production and intelligibility

Q7: language based intervention for sCAS or speech sound disorders

Works for all by all without need for specialists or SLPs

Need theory to know what doing, process

Morale

Language mediates motor function

Patterns or input output systems don't improve functioning

Respect

Need to understand how kids process information

Meaningful input supports sound production

Focus on language instead of sounds in isolation

Q8: referral to an SLP

No in private practice

Already referred

Appendix C

Graded Reading Passage

Selection D

The wind was blowing, and there were gray clouds in the sky.

"There is going to be some rough weather," said Dad. "Go into the cabin of the houseboat!"

Patty picked up Jingles, her kitten. She ran into the cabin and closed the door. She heard a crack of thunder and was so scared that she wanted to hide.

Suddenly the cabin door flew open. ^{Mittens} Jingles ran outside. "Come back, ^{Mittens} Jingles!" Patty cried.

A big wave splashed over the deck and washed the kitten into the water. Patty jumped after him.

Dad saw Patty jump. He grabbed a rope and threw it into the water.

Patty held onto the line. Soon she and Jingles were back on the houseboat.

^{Mittens}

Appendix D

Classroom artifact



