A CONCEPT KNOWLEDGE INTERVENTION

FOR CHILDREN WITH HEARING LOSS

by

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ABSTRACT

This study employed a single-subject design across behaviors and participants to measure the effects of classroom-based intervention on temporal and spatial concept word knowledge outcomes of children with hearing loss. This study aimed to 1) determine the functional relation between classroom-based intervention and concept vocabulary knowledge in preschool children with hearing loss as well as 2) identify both child-level and 3) intervention-level factors that improve or decrease their rate of concept vocabulary learning. The intervention used in this comparative single-subject design study followed a protocol based on Nelson, Powell, Bloom and Kraft (2014). Significant results were obtained for use of this intervention with spatial and temporal-spatial concepts, as one at least demonstration and two replications of a functional relation were demonstrated for these concepts. Results indicate the intervention increases in child concept knowledge immediately following instruction and with some maintenance; however, it is not intuitive to administer.

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Literature Review

Introduction

Even after receiving access to sound very early in life via optimal amplification, some children with hearing loss exhibit a deficit in vocabulary knowledge as compared to normal hearing peers (e.g., Lund, 2016). More specifically, children with hearing loss display a particular deficit in the acquisition of concepts, or vocabulary that cannot be fully defined using synonyms, which is necessary for describing the relation between objects (Davis, 1974; Englemann & Carnine, 1982; Small, 1990). Basic concepts (e.g., temporal and spatial concepts such as "early" or "on") differ from other concepts, such as object concepts (e.g., "car" or "house") or color concepts (e.g., "yellow" or "orange;" Boehm, 1976; de Villiers & de Villiers, 1978). Basic concepts are difficult for a child to create internal images of these ideas because their application can change depending on the situation (Boehm, 1982).

This lexical gap puts children with hearing loss at an academic disadvantage when compared to children with normal hearing. Basic concepts serve as a cornerstone for academic success and build both pre-reading and early mathematics skills because they are needed to label abstract concepts, problem solve, compare, and understand categories. An understanding of basic concepts is required to "directly compare two objects with a measurable attribute in common [e.g.,] which object has more of/less of an attribute," as dictated by the Common Core State Standards Initiative as an expectation for American kindergarten students (National Governors Association, 2010). Knowledge of basic concepts is essential for following teacher directions, understanding orders of events, and engaging in problem-solving activities (Boehm, 2001). Despite the clear connection between concept knowledge and academic success, research has not

yet established the best way to teach concept words to children with hearing loss. Although Nelson and colleagues (2014) suggested key intervention strategies, there is a lack of empirical evidence supporting the effectiveness of these approaches. Therefore, the aims of this study are to identify whether these instructional practices lead to improved concept vocabulary outcomes for children with hearing loss, and to consider the interaction between type of concept and effects of intervention.

Basic Concept Knowledge of Children with Normal Hearing

Concept vocabulary knowledge has been studied in children with normal hearing. Clark (1973) posed a theory of concept acquisition that involves three factors: a top-to-bottom hypothesis, non-simultaneous acquisition of semantically opposite terms, and semantic overextension. First, the top-to-bottom hypothesis refers to the idea that children learn concepts one semantic feature at a time and acquire broad, nonspecific concepts prior to acquiring more specific concepts. Data indicate this hypothesis to be true for children with normal hearing around ages four and five (Richards, 1979). Second, non-simultaneous acquisition of semantically opposite terms involves the categorization of concepts as “marked” or “unmarked” in an opposite pair. The unmarked term represents the characteristic being described in a positive way, rather than the opposite pole term. For example, “loud” is an unmarked concept because it refers to a greater number of decibels or how loud something is, whereas “quiet” is the opposite, marked term in the pair. Clark (1973) hypothesized that unmarked concepts are acquired before marked concepts. Bracken’s (1988) study of 1,109 preschool and primary grade children supported this theory, finding that 70% of 49 concept pairs followed a non-simultaneous sequence of development. Finally, semantic overextension refers to when a child associates a single term with that particular concept as well as semantically related concepts. For example, a

child may use the word “more” to refer to the concept “more” as well as to the concept “less.” Semantic overextension is typically exhibited by children between the ages of one and two-and-a-half years, until the child understands the meaning of both concepts in the conceptual pair. According to French & Nelson (1985), a student must be able understand a concept across various situations in order to fully comprehend it, as the application of basic concepts varies depending on the situation.

Boehm (2001) categorizes concept words into various types, such as size concepts (e.g., “medium-sized”), quantity concepts (e.g. “as many”), temporal concepts referring to time (e.g., “before” and “later”), and spatial concepts that describe an object’s position in space (e.g., “under” and “on”). However, some words in the Boehm classification have more than one conceptual meaning. For example, “before” is a term that can refer to spatial position or to temporal occurrence. Although the spatial position may be used to describe temporal meaning (as in a story sequencing activity), the literal spatial versus temporal meanings of words are not related. Spatial and temporal concepts serve different purposes in linguistic development. For example, temporal concepts, such as “before” and “after” are used when telling stories and sequencing events. Many basic concepts are learned when a child is in preschool, but do not become a part of the child’s repertoire until entering kindergarten (Boehm, 2001; Clark, 1983; de Villiers & de Villiers, 1978; French & Nelson, 1985). Because children with normal hearing do not struggle to learn concepts, there is no research to date considering the effects of intervention strategies on a child’s ability to learn them.

Vocabulary Instruction for Children with Normal Hearing

Though children with normal hearing can learn words through naturalistic means (Bloom, 2002), they sometimes require direct explicit instruction to learn vocabulary. This is particularly

true for children with low vocabulary knowledge (Coyne, Simmons, Kame'enui, & Stoolmiller, 2004). School-age children with normal hearing benefit from direct vocabulary instruction that incorporates the use of contextual information in teaching new words, gives definitional information, incorporates multiple exposures of target words, and encourages deep processing (National Institute of Child Health and Human Development, 2000). Furthermore, children with normal hearing are better able to learn new vocabulary when teaching incorporates semantic richness, or when additional semantic information is included in the instruction of the word (McGregor, Sheng, & Ball, 2007; Nash & Donaldson, 2005).

Vocabulary Knowledge and Learning for Children with Hearing Loss

It has been well established in the literature that children with hearing loss have low vocabulary knowledge when compared with normal hearing peers. More specifically, children with hearing loss have smaller lexicons, delayed acquisition of vocabulary knowledge, a slower rate of learning new words, and a narrower range of contexts that result in word learning (Cole & Flexer, 2007; Easterbrooks & Estes, 2007; Lederberg, 2003; Lederberg & Spencer, 2001; Marschark & Wauters, 2008; Paul, 2009; Rose, McAnally, & Quigley, 2004; Schirmer, 2000; Trezek, Wang, & Paul, 2010).

Lund (2016) analyzed 12 studies in the area of vocabulary knowledge of children with cochlear implants via meta-analysis. Findings indicated that children with cochlear implants performed lower than normal hearing peers matched for important factors, such as socioeconomic status on both expressive and receptive vocabulary tasks. The size of the gap in vocabulary knowledge was not affected by whether expressive or receptive measures were used (Lund, 2016). Further results of this meta-analysis showed that neither age of implantation, duration of neither implantation, nor chronological age at testing was significantly related to

vocabulary score differences between these populations. Therefore, these children must learn words at a faster rate than typically developing children to obtain a vocabulary that is comparable in size to normal hearing peers. Additional evidence indicates that a vocabulary gap between children with hearing loss and children with normal hearing persists well beyond stages of initial word learning. For example, Convertino and colleagues (2014) found that college-age individuals with hearing loss know fewer vocabulary words as compared to peers with normal hearing, and consequently demonstrate decreased world knowledge related to those words.

Concept Learning for Children with Hearing Loss

Although children with hearing loss tend to have the visual-spatial skills to support concept acquisition (Marschark, Morrison, Lukomski, Borgna, & Covertino, 2013), delays in word learning could also contribute to delayed academic concept acquisition and achievement (Houston et al., 2005; Qi & Mitchell, 2012). More specifically, children with hearing loss have a disadvantage on two levels when it comes to concept acquisition: first, a general word-learning deficit, and second, a possible difficulty in learning semantically complex words via linguistic means. Houston, Stewart, Moberly, Hollich, & Miyamoto (2012) reported that word learning deficits become more pronounced in children who wait longer to begin using amplification devices, and that children who were implanted with cochlear implants at relatively older ages scored lower on measures of receptive and expressive language than children who were implanted at a younger age. Relative to semantically complex words, children with hearing loss demonstrate documented deficits with non-concrete concept words (e.g., “then,” “yesterday,” “half”; Knoors & Marschark, 2014). Language samples from children between the ages of 3.5 to 4.5 who were implanted between 12 and 38 months of age revealed that earlier-implanted children knew a greater number of root words than children who received access to sound later in

life (Nicholas & Geers, 2007). Children who were implanted before the age of two demonstrated faster vocabulary and receptive language growth than children who were implanted after age five (Kirk et al, 2002). Although a large number of discrepancies exist in the literature regarding vocabulary knowledge of children with hearing loss, these studies further demonstrate that auditory deprivation impedes vocabulary knowledge and growth.

Effective Strategies for Teaching Basic Concepts

In 2014, Nelson et al. published a review paper describing six strategies as beneficial for teaching basic concepts to preschool children: concept isolation, positive examples, non-examples, continuous conversation, presentation of examples from general to specific, and generalization. These strategies serve to be facilitative for the child to develop an integrative and broadened understanding of the concept. During initial lessons, instructors should isolate concepts to avoid any confusion behind the term's meaning in order to increase the likelihood of a more rapid understanding (Martorella, 1972; Nelson et al., 2014). For example, a child may misunderstand the meaning behind the concept "red" if only shown red squares, and if all examples of "not red" were green circles (Engelmann & Carnine, 1982). In this case, there is a risk that the child would think the word "red" could be used to describe a square, as there would be two possible interpretations of the term. In this example, the teacher can increase the saliency of instruction by using a variety of colors to show examples of squares that are "not red."

The teacher should initially present several positive and distinctly unique examples of a concept so the child can generalize the concept's meaning to a variety of contexts (Nelson et al., 2014). Lessons should also include contrasting examples of the concept, referred to in the literature as "non-examples," in order for the child to learn the concept's key features and distinguish it from other concepts. Non-examples should demonstrate concepts that are already

in the child's lexicon so only one novel concept is introduced at a time (Tennyson & Cocchiarella, 1986). For example, when demonstrating the concept "under," non-examples would include placing an object on, in, and next to various objects. In this situation, the teacher could describe the location of the object using the phrase "not under" if the concepts "on" and "in" are not in the child's lexicon. These strategies help the child learn to distinguish that particular concept from another.

Demonstration of the concept should also take place in continuous conversation, as the teacher alternates between positive examples and non-examples. This strategy promotes the child's understanding of the concept by focusing on its key features, as the child is able to see the change while it is occurring (Simmons & Kame'enui, 1990). When a concept is demonstrated in continuous conversation, the child provided with examples of how the features of the object or idea change from one example to the next (Engelmann & Carnine, 1982).

Throughout the instruction of basic concepts, teachers should be conscious of the order in which concepts are taught and examples are presented (Nelson et al., 2014). It is recommended that teachers begin with easy trials, where positive examples are very similar to the target concept and non-examples are maximally different. Furthermore, Nelson et al. (2014) write that examples sharing the most features should be contrasted with one another, and instruction should move from simpler examples to more complex, in order to gradually familiarize the child with the concept. Furthermore, teachers should generalize the newly learned concepts by using several forms across a variety of contexts (Stokes & Baer, 1977).

Although utilization of these six strategies (concept isolation, positive examples, non-examples, continuous conversation, the order examples are presented, and generalization) has been agreed upon across a number of researchers in the area of basic concept instruction (Nelson

et al., 2014), no direction is provided regarding the types of words these strategies should be used to teach. Spatial concepts, unlike temporal concepts, can be represented visually, so it can be hypothesized that temporal concepts are more difficult to learn, and that perhaps different types of concepts require unique methodologies for their instruction. Moreover, the recommendations proposed by Nelson et al. (2014) are purely rooted in theory, as the effectiveness of these strategies has not yet been tested.

Teaching Vocabulary and Basic Concepts to Children with Hearing Loss

Research to date indicates that children with hearing loss are able to learn vocabulary more efficiently with early intervention, direct instruction, semantic richness, and repetition (Bobzien et al., 2015; Luckner & Cooke, 2010; Lund, Douglas, & Schuele, 2015). Luckner and Cooke (2010) reviewed research that addressed the vocabulary of children with hearing loss between the years 1967 and 2008. Only ten of these studies investigated the effects of intervention, half of which used broad terms, such as "early intervention," rather than describing a specific intervention practice. Barker (2003), Brooks et al. (1987), and Massaro & Light (2004) found that visual-tactile information facilitates vocabulary learning for children with hearing loss. A study by Paatsch et al. (2006) supports the notion that vocabulary instruction incorporating the oral discussion of word meaning, picture representation, and use of words in sentences is effective for vocabulary learning in children with hearing loss between the ages of 5 and 12 years. Furthermore, Robbins and Hatcher (1981) demonstrated that elementary school children with hearing loss who use Total Communication did not comprehend vocabulary words that were taught without additional semantic context.

More recently, studies have investigated the effect of specified vocabulary intervention protocol on vocabulary learning in preschool children with hearing loss. In a single-subject

multiple baseline design across five participants, Lund and Schuele (2014) found that preschool children with cochlear implants demonstrated a relation between rapid word-learning ability and a multicomponent intervention that included the identification of novel words, phonological rehearsal, and inclusion of additional semantic information. Lund et al. (2015) conducted one of the first studies of classroom-based intervention effects of general vocabulary learning in children with hearing loss, demonstrating that preschool children with hearing loss benefitted from the inclusion of additional semantically rich information more than when vocabulary was taught in isolation. This was found to be particularly true when children with low vocabulary knowledge participated in physical interaction experiences when learning the new words. Bobzien and colleagues (2015) employed a single-subject, multiple-baseline design, demonstrating that explicit vocabulary word instruction embedded within repeated readings of a text increased vocabulary knowledge in four preschool children with hearing loss. Additionally, using an adapted alternating-treatments single-subject experimental design, Lund and Douglas (2016) demonstrated that preschool children with hearing loss have better vocabulary learning outcomes when taught with explicit, direct instruction, rather than indirect, naturalistic teaching strategies (follow-in labeling and incidental exposure).

Despite what is known about strategies to improve general vocabulary learning for children with hearing loss, there is currently no research to support methods of teaching concepts to children with hearing loss, or whether methods differ by type of concept words. Furthermore, there is currently no research to date regarding the instruction of vocabulary terms with dual meanings, particularly for children with hearing loss. Although Nelson et al. (2014) recommended specific strategies for teaching concepts to children with hearing loss, as previously described, the subsequent impact on a child's lexicon has not yet been identified.

Chapter II

Purpose

When compared to their normal hearing peers, preschool children with hearing loss have smaller vocabularies, learn words at a slower rate, and tend to learn different types of words (Nott et al., 2009a; Nott et al., 2009b). In particular, children with hearing loss demonstrate documented deficits with non-concrete words, such as "concept" words (e.g., "then," "yesterday," "half"; Knoors & Marschark, 2014). These vocabulary deficits in early childhood likely contribute to later academic delays that are well-documented in persons with hearing loss (Qi & Mitchell, 2012). However, the word-learning skills of children with hearing loss are malleable; that is, with intervention, children with hearing loss can improve their rate of word learning (Lund & Schuele, 2014). Although some studies to date have demonstrated that educators can improve the word-learning abilities of children with hearing loss (e.g., Lund, Douglas, & Schuele, 2015), no study to date has explored the relation between teaching strategies and concept-word knowledge.

Research Questions

This study will evaluate an intervention protocol designed to teach concept words to children with hearing loss (Nelson et al., 2014). The study will employ a single-subject, multiple-baseline design across behaviors and participants to measure the effects of the independent variable, intervention, on learning outcomes for temporal concept words, spatial concept words, and temporal-spatial concept words. Specific research questions for this study are as follows:

1. Is there a functional relation between the Nelson et al., 2014 classroom-based intervention and learning concept words with a temporal-only meaning?

2. Is there a functional relation between the Nelson et al., 2014 classroom-based intervention and learning concept words with a spatial-only meaning?
3. Is there a functional relation between the Nelson et al., 2014 classroom-based intervention and learning concept words with a temporal-spatial meaning?
4. What child-level factors improve or decrease the rate of concept vocabulary learning in preschool children with hearing loss?

Chapter III

Methodology

Participants

Nine participants (five males and four females) who ranged in age from approximately 3 to 6 years were recruited from an auditory-oral preschool for children with hearing loss, where all students learn to speak using hearing aids or cochlear implants. Teachers at this preschool communicate only using spoken language and do not use manual communication, such as American Sign Language. Children were eligible to participate if they had an audiological diagnosis of at least a mild hearing loss per parent report, normal vision, and at least one cochlear implant device or hearing aid of any brand that provided enough amplification to access the full range of speech sounds. All of the children in the study came from two-parent, middle to upper-middle class families. See Table 1 for individual child profiles.

Child	Chronological Age	Amplification Used	Age at Amplification	Degree of Loss	Other Diagnoses
A	3;11	Bilateral HA	2 months	R/L: Moderate sloping to Severe	
B	4;3	Bilateral CI AB	16 months	R/L: Severe-Profound	
C	5;4	Bimodal HA/CI MED EL	32 months	R: Mild sloping to Severe L: Profound	Mondini, facial paralysis
D	4;2	Bilateral CI MED EL	12 months	R/L: Profound	
E	3;7	Bilateral HA	5 months	R/L: Moderate to Moderate-Severe	
F	5;0	Bilateral CI AB	14 months	R/L: Severe to Profound	
G	4;7	Bilateral CI Cochlear	11 months	R/L: Profound	
H	4;9	Bilateral CI	R: 14 months	R/L: Profound	

	Cochlear	L: 21 months

Note: HA = Hearing Aid; CI = Cochlear Implant; AB = Advanced Bionics

Table 1. Individual Child Profiles

Overall language, expressive and receptive vocabulary, articulation, nonverbal intelligence, and basic concept scores of each participant were collected from student records at the preschool where the study took place. See Table 2 for participant profiles.

Child	Receptive Vocabulary	Expressive Vocabulary	Overall Language	Articulation	Nonverbal Cognition	Basic Concepts
A	95	128	114	111	93	115
B	91	107	81	90	97	92
C	75	90	74	66	87	81
D	102	102	90	97	126	88
E	97	105	102	99	120	92
F	107	108	100	91	119	104
G	110	124	110	118	109	106
H	99	108	112	106	105	100

Note: Articulation assessed via the Arizona Articulation Proficiency Scale–Third Edition (Fudala, 2000) or Goldman Fristoe Test of Articulation–2 (Goldman & Fristoe, 2000). Overall language assessed via the Preschool Language Scale–Fifth Edition (Zimmerman, Steiner, & Pond, 2010). Expressive vocabulary assessed via the Expressive One Word Picture Vocabulary Test–Fourth Edition (Martin & Brownell, 2010a) or Expressive Vocabulary Test (Williams, 2007). Receptive vocabulary assessed via the Receptive One Word Picture Vocabulary Test–Fourth Edition (Martin & Brownell, 2010b) or the Peabody Picture Vocabulary Test–Fourth Edition (Dunn & Dunn, 2007). Nonverbal intelligence assessed with the Kaufman Brief Intelligence Test, Second Edition (Kaufman & Kaufman, 2004). Basic Concepts assessed via the Bracken Basic Concept Scale–Third Edition (Bracken, 2006). Because all measures are standard scores, the mean of all measures is 100 with a standard deviation of 15.

Table 2. Child Assessment Standard Scores

Settings

This study was conducted at an auditory-oral, private preschool for children with hearing loss in the Midwestern United States. Intervention took place in four separate 900 square foot classrooms, consisting of approximately six students in each class. During vocabulary instruction, students were seated on a carpet or at a small and were able to view the teacher without obstruction at a distance of approximately three feet. Probe assessments took place in a 600 square foot classroom, where the participant was seated at a table facing the teacher at a

distance of approximately two feet. Every classroom in the preschool was sound treated to decrease background noise and acoustic conditions have been surveyed by an educational audiologist to ensure the signal to noise ratio (SNR) is within recommended limits according to American National Standards Institute (ANSI) standards. All teachers participating in this study wore personal frequency modulation (FM) systems to maximize each child's auditory access during both classroom instruction and probe assessment.

Materials

Teachers used toys from the general toy supply of the classroom, which were approximately five to fifteen inches in length when implementing vocabulary instruction, as well as classroom furniture to demonstrate spatial concepts (i.e., placing a toy under a chair to demonstrate the concept "under"). Each teacher recorded one session every week using an Apple iPad. Items used in the probe assessment included labeled boxes with the materials outlined in Appendix A. The toys used in the probe assessment were preselected to be approximately five to fifteen inches tall, appropriate for preschool children, and representative of vocabulary known to the participants of the study. The teachers referenced the concept probe assessment (Appendix A) when administering probe items.

Response Definitions and Measurement System

The central hypothesis of this study was that implementation of the intervention described by Nelson and colleagues (2014) would positively impact the word-learning abilities of children with hearing loss for spatial concepts more so than temporal concepts. In order to test this hypothesis, words were selected based on initial performance on the *Bracken Basic Concept Scale–3* (Bracken, 2006; BBCS-3), and were then categorized as spatial, temporal, and temporal-spatial.

The probe assessment was developed based on the concept words identified from the BBCS-3 (see Appendix A). The authors of this study constructed four assessment boxes with materials necessary for the probe assessments. The boxes were categorized by spatial terms (e.g., above), temporal terms (e.g., morning, new, finish), spatial-temporal terms referring to the temporal meaning of the word (spatial-temporal: spatial terms or STS), and spatial-temporal terms referring to the spatial meaning of the word (spatial-temporal: temporal terms or STT). Spatial-temporal terms are those that have two meanings and can either be used to indicate time or place. For example, the word "first" may refer to its spatial meaning, such as being the *first* in a line, or its temporal meaning, such as being the *first* to jump up and down. The authors determined five words from each of these categories to be instructed and assessed throughout the duration of the study by selecting concepts that all children in a particular class missed on the BBCS-3 assessment (see Table 3).

Administration of this probe assessment was approximately five minutes per child, and the teacher administered the probe by placing the necessary materials in front of the child while reading the instructions provided on the concept probe assessment sheet (see Appendix A) (e.g., "Put the dog above the blocks"). The examinee responded by manipulating the objects to indicate the response. Teachers noted whether the students demonstrated the correct response on a score sheet (Appendix B) and sent the score sheet to the researchers via email. Although formal basic concept assessments, such as the BBCS-3, require the examinee to point to a picture of the correct response, this mode of assessment was implemented to utilize an open-set response by giving the child the opportunity to generate one of multiple possible responses, thereby minimizing the child's opportunity for guessing. The dependent variable in this study was the

percent of concepts understood, as exhibited by correctly manipulating objects in response to a verbal prompt.

Class	Spatial Terms	Temporal Terms	Spatial-Temporal Terms
1	Above	Always	After
	Back	As soon as	Begin
	Below	Then	Between
	Edge	While	Final
	Near	Yesterday	Through
2	Above	Early	After
	Ahead	Late	Around
	Center	Leaving	Close to
	Edge	Morning	Final
	Low	Never	Fourth
3	Above	Early	After
	Back	Finished	First
	Beside	Never	Last
	Edge	New	Second
	Left	While	Third
4	Above	Always	After
	Below	As soon as	Begin
	Between	During	Between
	Front	Early	Final
	Toward	While	Through

Table 3. Instructed Concepts by Class

Interobserver Agreement Procedures

The principal of the preschool, a co-author of this study, observed 40% of probe assessment data collection to ensure that assessment was administered appropriately and that data was collected correctly. An independent observer and the first author collected agreement data for 100% of probe assessments across all word types by entering the data from the score sheets into tables and calculating percent correct across conditions. Any disagreements were reviewed until a final comparison of the tables indicated 100% agreement between the first author and the observer. Any disagreements were reviewed to ensure proper data collection. Observers were blind to intervention procedures and to prevent bias in their scoring.

Experimental Design

A single-subject, multiple probe treatment design was employed to measure the effectiveness and efficiency of the Nelson et al., 2014 classroom-based intervention on concept learning for children with hearing loss (Kratochwill et al., 2010). Decisions were based on the performance of the majority of the students, as this is how decisions are typically made in a classroom setting. The authors selected a multiple probe design because concept acquisition is a learned rather than reversible behavior, and the purpose of this study was to compare individual student performance on a concept knowledge probe assessment to performance at baseline (Gast & Ledford, 2009). This study was approved by the Texas Christian University and Vanderbilt University institutional review boards. The initiation of the intervention phase was staggered and the introduction of each type of concept was varied across classes to account for threats to internal validity, including carryover effect and threat of maturation (Orlikoff et al., 2015; Christensen, 2007).

Experimental Conditions and Procedures

Teacher training. Four master's-level teachers of the deaf participated in an hour-long live training with the authors via Skype to learn the protocol procedures for this study. The authors provided an explanation of the purpose of the study, described and demonstrated the study's protocol, and provided the teachers with the fidelity checklist (see Appendix C) that would be used to score the teacher's compliance with procedural fidelity. Furthermore, the teachers were provided with a video-recorded example of the protocol procedures to reference throughout the course of the study.

Intervention. Each child participated in the intervention for no more than 30 minutes during each day of the preschool's summer enrichment program, which was offered three days a

week for six weeks. Four teachers participated in this study with up to three participants in each classroom, as delineated in Table 4. The order of behaviors was counterbalanced across classrooms, by randomizing the order that each category of concept would be taught (i.e., spatial, temporal, STS, or STT). Each teacher was provided with five concept words to teach from a particular category, which were chosen based on words that all students in the class did not know as determined from initial student performance on the Bracken Basic Concept Scale (Bracken, 2006). Each day the same word list was used in the intervention and the probe assessment, in addition to a list of five words from another category. For example, if a class was learning a list of five spatial concepts, the probe assessment may consist of the same five spatial words and five temporal words. Decisions were made to move on to the next concept category when the majority of the participants in a given class demonstrated mastery of 80% of the concepts from taught that day. The teachers video recorded one vocabulary lesson for one day of each week in order to check for procedural fidelity because the school was in a remote setting from the authors of the study. The day for video recording was selected randomly and communicated by the first author to the teacher at the beginning of the week.

Classroom	Classroom 1	Classroom 2	Classroom 3	Classroom 4
Participants	Student A Student B	Student C	Student D Student E	Student F Student G Student H

Table 4. Participants in Each Classroom

The intervention protocol was adapted from Nelson et al. (2014). The intervention consisted of three phases: (1) an introduction to the concepts, (2) receptive practice, and (3) expressive practice. During the introduction phase, concepts were isolated and taught one concept at a time. The teacher would say the name of the new concept and ask the children to repeat the name of the concept. The teacher would then alternate at least three times between

providing five positive and five negative examples for each concept in at least three different contexts. For example if the concept was “under,” the teacher could show “under the chair,” “under the table,” and “under a box” as three different contexts. Instruction began with the most obvious examples and moving to more abstract examples (e.g., the teacher would start with “under” table before introducing “under” a window). For the receptive practice phase, the teacher would hand at least one child an object or a picture and ask the child to demonstrate the concept. Finally in the expressive practice phase, the teacher would ask each child to use the word productively in an obligatory context. For example, the teacher would ask, “Oh look! Where is the dog?” in the example of “under.”

Procedural Fidelity Data Collection

An independent observer and the first author collected procedural fidelity agreement data for 25% of all video recorded intervention sessions. The observer was trained in coding fidelity for this study by watching a practice intervention video and checking off the number of individual steps of the intervention protocol that were completed. To calculate values for procedural fidelity, the number of steps each teacher adhered to was divided by the number of steps listed on the fidelity checklist (see Appendix C), as described previously, and multiplied by 100. This formula was adapted from Lund & Douglas (2016). Because over 80% of the ratings by the first author and the independent observer were in agreement at a point-by-point level, the first author’s coding was used for procedural fidelity analysis.

Data Analysis Plan

Data was collected and graphed after each probe assessment. Eight line graphs were created, one for each participant, to represent individual student performance throughout the duration of the study. The graphs clearly indicated which days each type of concept was taught,

and when the decision was made to move on to a new type of concept. A functional relationship was determined when there was one demonstration of clear learning for a particular type of concept and at least two replications. It was determined that clear learning took place when a child demonstrated at least 80% accuracy on the receptive probe assessment.

Chapter IV

Results

Two forms of baselines were collected in order to measure progress of the dependent variable. Initially, all students were administered the BBCS–3 (Bracken, 2006) to determine which concepts the students did not yet know in order to determine which concepts would be taught for the purpose of the study. These will be referred to as pre-initiation baselines throughout this paper. Additionally, post-initiation baselines for concepts in each category were collected throughout the duration of the study before introduction of instruction for the respective terms using the probe assessment previously described in the Response Definitions and Measurement System section of this paper. These post-imitation baselines were collected with the assumption that instruction of one group of concepts may influence acquisition of other concepts. It should also be noted that because this study took place in an ecologically valid setting (a preschool classroom), participant attendance was affected by the school-year calendar of both the participants and the preschool. Consequently, not all participants were present for every session.

Procedural Fidelity

A significant factor in this study is the fidelity with which teachers adhered to the teaching protocol. The ability of a teacher to implement a vocabulary lesson with fidelity will necessarily affect both child learning and validity of the study's results. Following completion of the study, the first author and a trained observer evaluated approximately one-third of all sessions, which were video recorded and sent to the author, to determine whether the teachers were adhering to the treatment's procedures. Procedural fidelity varied widely across teachers, and this is important to consider when interpreting the study's results. Specifically, the teachers

implemented 69.06% (Teacher 1), 86.87% (Teacher 2), 85.68% (Teacher 3), and 65.61% (Teacher 4) of the steps of the treatment on average.

Teacher 1 fell below 80% procedural fidelity during 66% of observed sessions, on days 6 and 7. This teacher was observed to provide examples that were identical to the probe assessment, thereby compromising the integrity of the children's scores and contributing to her decline in fidelity percentage. Teacher 4 did not meet the 80% criteria for fidelity on days 1, 4, 6, or 8, which comprised 100% of observed sessions. During all observed lessons, she did not teach at least five positive or negative examples for each word, and she did not move between positive and negative examples at least three times for each word. On days 6 and 8, she also did not indicate the purpose of the lesson or ask the children to repeat all of the new words.

When controlling for number of days a word was taught on the relation between procedural fidelity and percent correct receptive concept knowledge, we find the following partial correlations respectively (Teacher 1, Teacher 3, and Teacher 4): r = -.492, p = .161; r =-.18, p = .349; and. r = .822, p = .022. Due to insufficient data points, statistics for Teacher 2 could not be run for this correlation.

Concept Knowledge Learning

Knowledge of concept mastery was calculated for each child based on performance during a probe assessment collected during each day of the study. Figures 1 through 8 display results for all participants as well as the percent of procedural fidelity in the corresponding classrooms. Each graph, without labels, was sent to an observer trained in single-subject design who was naïve to the study purpose. A functional relation was assumed when both observers agreed that a shift in the dependent variable level corresponded to the introduction or removal of the independent variable.

In Class 1, Student A demonstrated a functional relation between percent correct on a receptive task of concept knowledge and the introduction of instruction for STT, STS, and temporal concepts. Her performance yielded 100% non-overlapping data between baseline and intervention conditions for these concepts. Her results did not, however, display a functional relation between these variables for spatial concepts, as she demonstrated 100% receptive knowledge of these concepts at the post-initiation baseline. This student maintained 100% accuracy for STT, STS, and spatial concepts, whereas her performance for knowledge of temporal concepts decreased from 100% to 80% accuracy during the maintenance phase. Student B demonstrated a functional relation and yielded 100% non-overlapping data between baseline and intervention conditions for temporal and spatial concepts, but not for either group of spatial-temporal concepts. In the maintenance phases, he demonstrated preservation of STT concept knowledge, whereas STS concept knowledge fell below 80% after instruction of these concepts ended. The latencies for all participants are represented in Tables 4 through 7 in the order that the concepts were taught for each class. These tables represent the number of days that each student was taught a particular type of concept before researching the 80% mastery criteria on the probe assessment.

Student C, the only study participant in Class 2, demonstrated a functional relationship for temporal, spatial and STS concepts. Although Class 2 was not explicitly taught STT concepts, Student C's performance on these words improved throughout the study, as well, with 100% non-overlapping data between pre-initiation baseline and post-initiation baseline conditions. This improvement may be attributed to carryover from the instruction of the spatial meaning of these same terms. This student yielded 100% non-overlapping data between pre-initiation baseline and intervention conditions for temporal concepts; however, he did not

demonstrate maintenance of knowledge for these concepts. He also yielded 100% non-overlapping data between post-initiation baseline and treatment conditions for spatial concepts.

Two children in Class 3 participated in this study: Student D and Student E. Student D's results demonstrated a functional relationship with 100% non-overlapping data between the baseline and intervention phases for spatial and STT concepts, with generalization of knowledge present for spatial terms. A functional relationship was not evident for temporal or STS concepts. Student E demonstrated a functional relationship between baseline and intervention phases with 100% non-overlapping data for both temporal and STT concepts, but not for STS or spatial concepts.

Class 4 included three students who were involved in this study: Students F, G, and H. Results of the performances for both F and G did not indicate a functional relationship for any of the concepts taught between baseline and intervention phases. The teacher in Class 4 did not teach temporal concepts due to time constraints, and Students F and G both did not demonstrate that they had acquired knowledge of these concepts during post-initiation baselines. Student H, however, did show some demonstration of learning of the temporal concepts, even though they had not been explicitly taught in the classroom, with 100% non-overlapping data between pre-initiation baseline and intervention phases. Additionally, Student H demonstrated a functional relationship for STT and spatial concepts, with 100% non-overlapping data between pre-initiation baseline and intervention phases as well as some maintenance of STT concept knowledge.

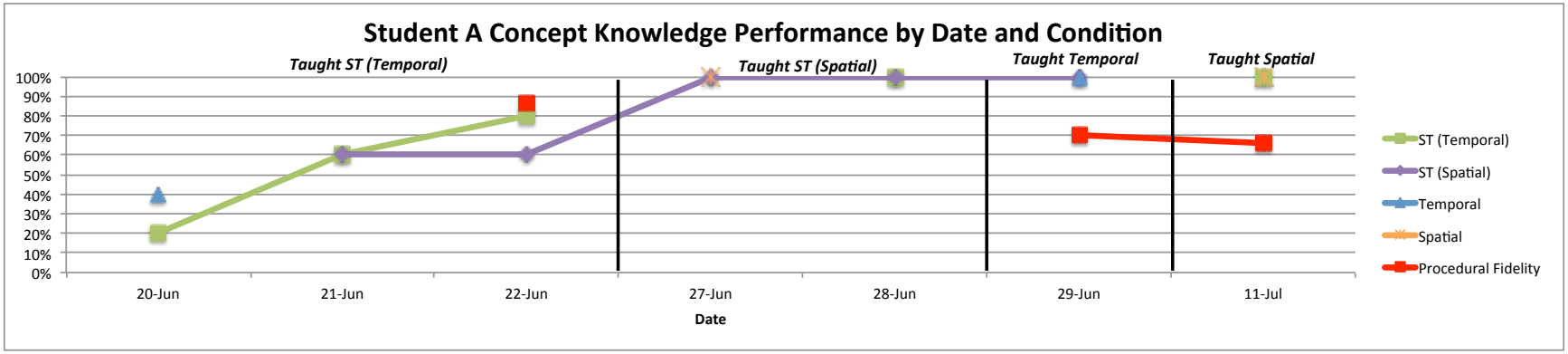

Figure 1. Student A Concept Knowledge Performance by Date and Condition

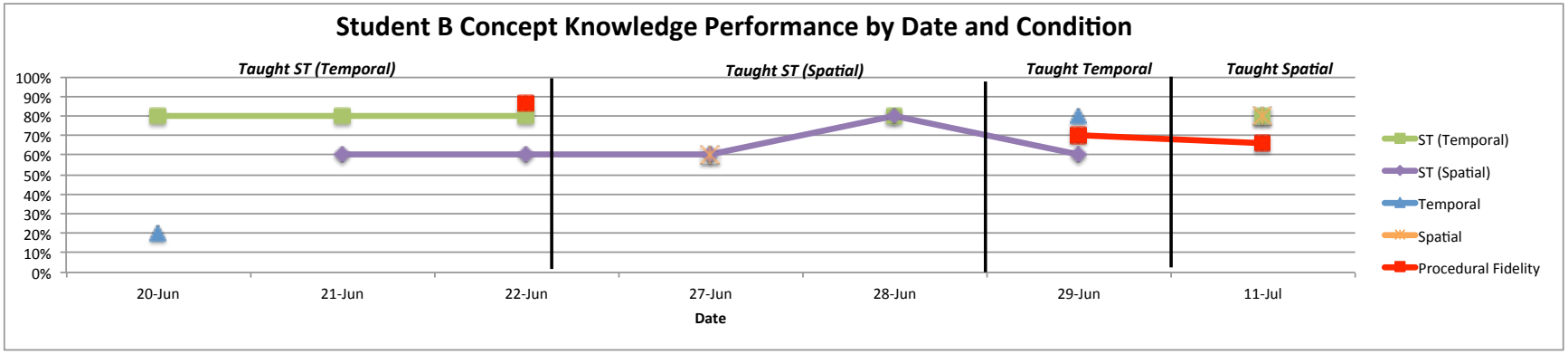

Figure 2. Student B Concept Knowledge Performance by Date and Condition

	Spatial Temporal (Temporal)	Spatial Temporal (Spatial)	Temporal	Spatial
A	3	1	1	1*
B	1	2	1	1

** = reached 80% on post-initiation baseline*

Table 5. Class 1 Latency to 80% Accuracy

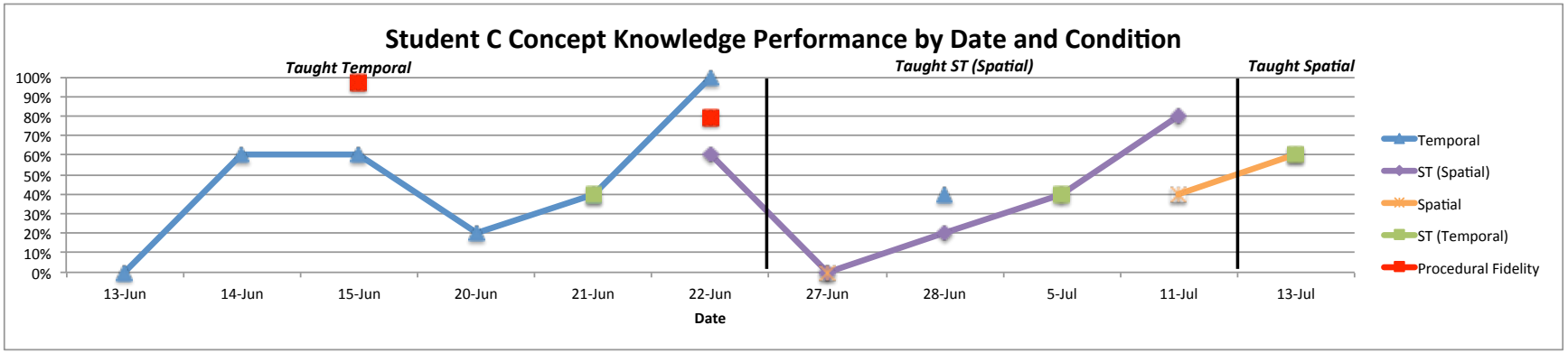

Figure 3. Student C Concept Knowledge Performance by Date and Condition

	Temporal	Spatial Temporal (Spatial)	Spatial	Spatial Temporal (Temporal)
C	6	4	*TNM*	*NT*

TNM = taught, no mastery, NT = not taught

Table 6. Class 2 Latency to 80% Accuracy

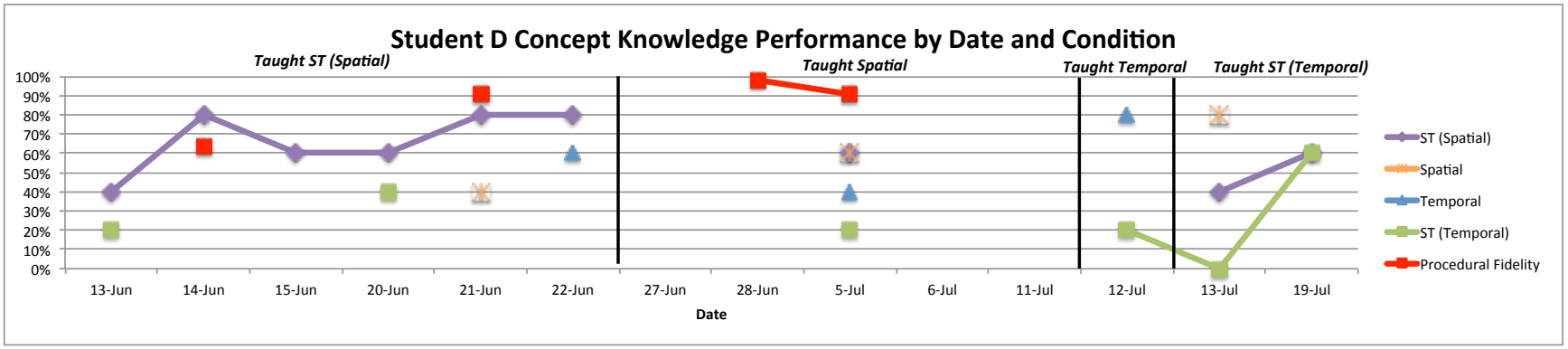

Figure 4. Student D Concept Knowledge Performance by Date and Condition

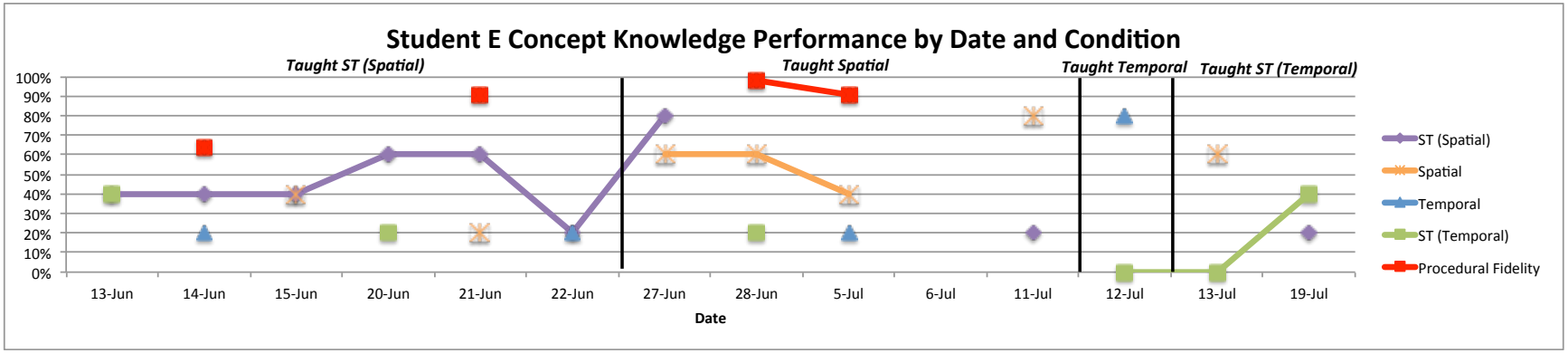

Figure 5. Student E Concept Knowledge Performance by Date and Condition

	Spatial Temporal (Spatial)	Spatial	Temporal	Spatial Temporal (Temporal)
D	2	*TNM*	1	*TNM*
E	*TNM***	4	1	*TNM*

Table 7. Class 3 Latency to 80% Accuracy

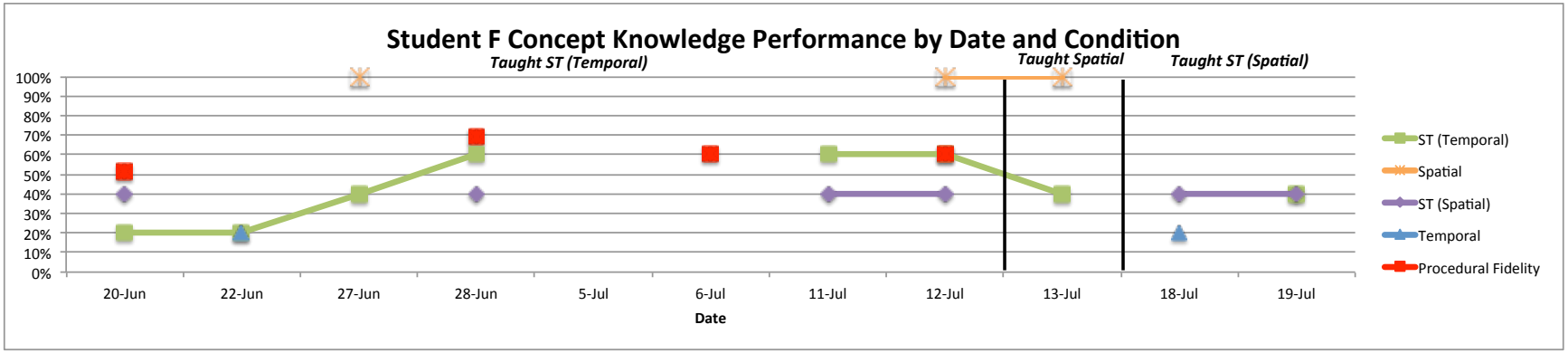

Figure 6. Student F Concept Knowledge Performance by Date and Condition

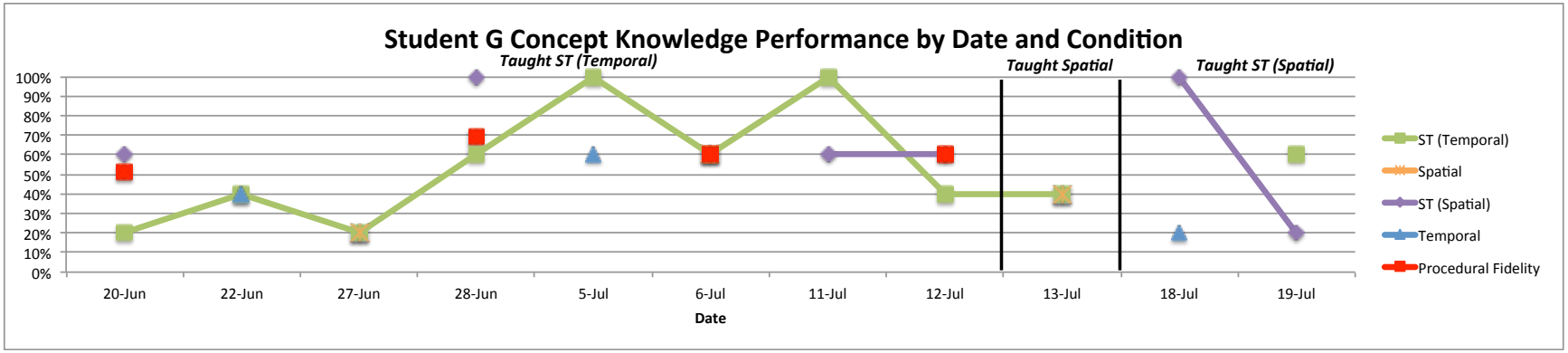

Figure 7. Student G Concept Knowledge Performance by Date and Condition

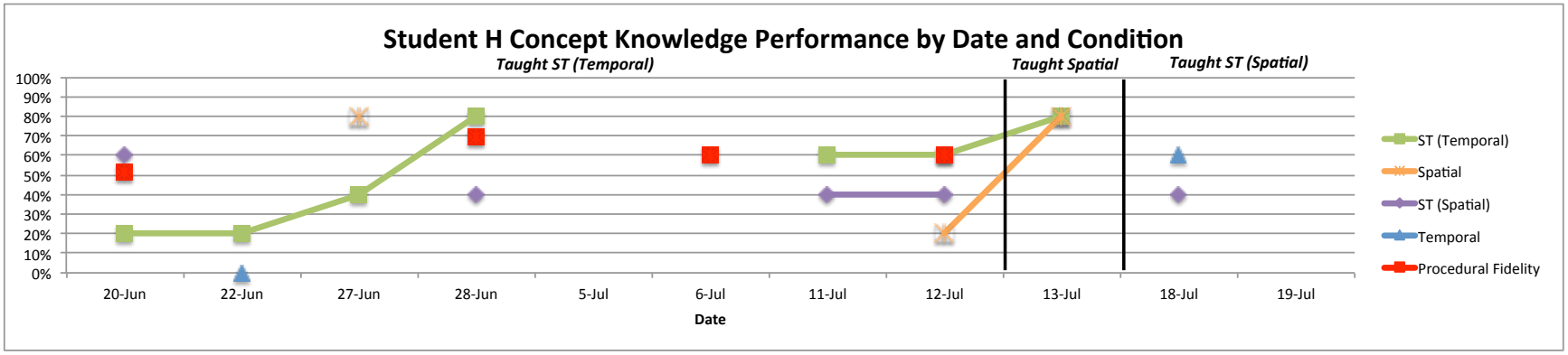

Figure 8. Student H Concept Knowledge Performance by Date and Condition

	Spatial Temporal (Temporal)	Spatial	Spatial Temporal (Spatial)	Temporal
F	*TNM*	1*	*TNM*	*NT*
G	5	*TNM*	1*	*NT*
H	4	1*	*TNM*	*NT*

Table 8. Class 4 Latency to 80% Accuracy

Chapter V

Discussion

This study investigated the existence of a functional relation between classroom instruction of spatial, temporal, and temporal-spatial basic concepts and subsequent effects on measures of concept knowledge acquisition in preschool children with hearing loss. There is not currently established literature on ways to teach concepts to children with hearing loss, despite the necessity of concept knowledge for academic success as early as kindergarten. Nelson et al. (2014) introduced an intervention because of this clear need to effectively teach concepts to children with hearing loss. However, to date, no study has validated the Nelson intervention protocol, particularly for children with hearing loss. Results of this study indicate that adherence to the Nelson et al., 2014 classroom-based treatment protocol does correlate with concept learning for some children with hearing loss, and is perhaps more predictive of classroom performance than individual child variability.

Standardized Assessments of Concept Knowledge

An interesting finding in this study was that performance on the BBCS–3, a norm-referenced and standardized assessment of concept knowledge, did not align with performance on our criterion-referenced probe assessment. Specifically, there were 4 instances when a child's performance on our probe assessment prior to any teaching (the "pre-initiation baseline") revealed mastery of a category of concepts after performance on the BBCS–3 indicated that the child did not know these concepts. We suspect that our probe assessment measured concept knowledge more accurately because the object manipulation nature of the assessment minimized the child's opportunity for guessing and allowed for the opportunity to generate one of multiple possible correct responses. This distinction in performance between these two measures signifies

that the BBCS–3 may not be measuring complete concept knowledge, but rather, concept knowledge according to one particular situation (or a two-dimensional picture), demonstrating a need for further research in this area.

Participant Variability and Procedural Fidelity

The variability of the participants across test scores, type of amplification, and age of amplification should be noted. At the preschool where this study took place, preschool classes are grouped based on ability. For example, the students in Class 4 (Students F, G, and H), who all have bilateral cochlear implants, achieved the highest test scores prior to implementation of this study. The performance of these students placed them above the mean on at least five of the six standardized tests administered in the areas of receptive vocabulary, expressive vocabulary, overall language, articulation, nonverbal cognition, and basic concepts. It was, therefore, surprising that these students had the most variable performance across classes. Upon review of the videos of this classroom's instruction, however, it became clear lack of adherence to procedural fidelity might have contributed to the variability in student performance. This discrepancy between test scores and performance in the classroom highlights the importance of monitoring procedural fidelity throughout the duration of a study rather than after a study's completion.

Student C's performance yielded the lowest scores throughout initial testing, as his scores placed him below the mean on all standardized measures. This initial performance, as well as his other diagnoses of Mondini dysplasia and facial paralysis and later age of implantation (32 months), led us to predict that Student C would have more difficulty learning concepts compared to his higher-scoring peers; however, this student demonstrated a clear learning of all concept categories instructed in his classroom. The clear functional relations exhibited by Student C in

conjunction with the consistent adherence to procedural fidelity by his teacher in Class 2 reinforces our conclusion that procedural fidelity may play a greater role in improving child learning when compared to individual child profile.

Type of Concept Words

The results of this study have been further analyzed by considering the relation between type of concept and effects of intervention. The performance of students in Class 1 is not included in this analysis because the tendency to provide instruction identical to the probe assessment invalidates these results. A functional relation between the Nelson et al. 2014 classroom-based intervention and learning of concept words with a temporal meaning was established for Students C and E, and Student H demonstrated some learning for these concepts as well. These students did not, however, demonstrate maintenance for these concepts. These results do not yield significant findings for temporal concepts, signifying that this intervention may or may not be effective for teaching temporal concepts. Significant results were obtained, however, for instruction of spatial concepts using this intervention, as students C, D, and H all demonstrated a functional relation between these variables.

A functional relation was established between the Nelson et al. 2014 classroom-based intervention and learning of concept words with a temporal-spatial meaning for Students C, D, E, and H, yielding significant results for these concepts (one demonstration and three replications). Only one of these three students, however, demonstrated generalization of learning between the temporal and spatial meanings of the same spatial-temporal concepts. Therefore, we cannot assume that a child's knowledge of the spatial meaning of a temporal-spatial concept carries over to the temporal meaning, and vise-versa. Many teachers might not be aware that there is a difference between these two meanings, and that they are essentially different concepts

altogether. This was clear during the study, as some teachers would instruct on both temporal and spatial meanings of words when they were only supposed to teach examples of one meaning of the word (these initial lessons that were not included in the data collection for this study).

Limitations and Future Research

These results should be interpreted within the context of the following limitations. First, it should be noted that the vocabulary instruction our study slightly differed from the recommended procedures by Nelson et al. (2014), which was a limitation of our study. The intervention recommended by Nelson et al. (2014) included teaching a minimum of six to eight positive examples for a single concept in a 20-minute lesson. The ecological validity of this suggestion should be considered, as it is not particularly realistic to adhere to these requirements in a preschool classroom where teachers may not have the time to spend 20 minutes teaching a single vocabulary term. Our procedures, therefore, involved the instruction of three to four concepts in a 20-minute lesson, with a minimum requirement of only five positive examples for each concept. Future studies should consider implementing the suggestions offered by Nelson et al. (2014) exactly as they are presented to determine how realistic these suggestions are in the context of a functioning classroom. Furthermore, future studies should incorporate the implementation of teacher satisfaction surveys to gain further understanding of the ecological validity of these procedures, including the teacher's opinion of varying aspects of the intervention. After all, no intervention can be effective without teacher buy-in. In order to ensure that procedures of the intervention proposed by Nelson et al. are correctly implemented, procedural fidelity should be monitored throughout the duration of future studies, rather than at after its completion.

Second, results indicate that the intervention proposed by Nelson et al. (2014) may not be particularly intuitive, as many of the teachers frequently did not adhere to procedural fidelity. This is consistent with previous research, as Nelson et al. (2014) found that only 12% of teachers in their study of typical practice procedures used non-examples and only 4% incorporated continuous conversation into their lessons. The correlation between fidelity and performance in Class 4 is significant and strongly positively correlated; this teacher did not meet the 80% criterion for fidelity for any of her observed sessions and her students were the lowest-performing in our study (despite having the highest language scores on standardized measures). On the other hand, a negative correlation was found between these variables for Class 1. The Class 1 teacher had lowered fidelity because instead of not following procedures, as with Class 4, this teacher taught examples directly from the probe measure. This finding indicates that teaching to the test, as this teacher demonstrated in a majority of her observed sessions, will improve student performance even after only teaching for a few days. The limited adherence to procedural fidelity of some of these teachers highlights the importance of monitoring this variable throughout the course of any study in order to ensure accuracy of findings.

Third, the context of this study limited the number of data points that could be collected. This study took place at the Mama Lere Hearing School summer enrichment program, which was only offered three days a week for six weeks. Additionally, initial days of concept instruction were not included in the data collection for this study, as previously noted, due to confusion over the difference between the temporal and spatial meanings of temporal-spatial concepts. The lists of words which were instructed to these children also needed to be adapted after early sessions, as student performance on the probe assessment indicated that some of the students had knowledge of certain concepts, despite performance on the Bracken indicating

otherwise. Perhaps more information could be obtained from future studies that take place over a longer timespan.

Conclusions

The results of this study indicate that the Nelson et al. (2014) intervention is a potentially effective way to teach basic concepts to preschoolers with hearing loss. However, teachers had difficulty adhering to procedural fidelity and establishing maintenance of knowledge once instruction had moved on to new vocabulary words. Nevertheless, correct use of this intervention did result in increases in child concept knowledge immediately following instruction and with some maintenance. This study contributes to the limited literature on instructional methods for vocabulary knowledge of children with hearing loss, which is essential for further learning and academic success.

References

Barker, L. J. (2003). Computer-assisted vocabulary acquisition: The CSLU vocabulary tutor in oral-deaf education. *Journal of Deaf Studies and Deaf Education, 8*(2), 187-198.

Bloom, P. (2002). *How children learn the meanings of words*. Cambridge, MA: MIT Press.

Bobzien, J. L., Richels, C., Schwartz, K., Raver, S. A., Hester, P., & Morin, L. (2015). Using repeated reading and explicit instruction to teach vocabulary to preschoolers with hearing loss. *Infants and Young Children*, *3*, 262–280. doi:10.1097/IYC.0000000000000039

Boehm, A. E. (1976). *Boehm Resource Guide for Basic Concept Teaching.* New York: The Psychological Corporation.

Boehm, A. E. (1982). Assessment of basic concepts. In K.D. Paget & B.A. Bracken (Eds.), *The Psychoeducational assessment of preschool children* (145-161). New York: The Psychological Corporation.

Boehm, A. E. (2001). *Boehm Test of Basic Concepts–3* (*manual*). New York: The Psychological Corporation.

Bracken, B. A. (1988). Rate and sequence of positive and negative poles in basic concept acquisition. *Language, Speech, and Hearing in Schools, 19,* 410–417. doi: 10.1044/0161-1461.1904.410.

Bracken, B. (2006). *Bracken Basic Concept Scale–3* (*manual*). San Antonio, TX: Pearson Assessments.

Brooks, P. L., Frost, B. J., Mason, J. L., & Gibson, D. M. (1987). Word and feature identification by profoundly deaf teenagers using the Queen's University tactile vocoder. *Journal of Speech, Language, and Hearing Research*, *30*(1), 137-141.

Christensen, L. B. (2007). *Experimental methodology* (10th ed.). Boston: Pearson/Allyn & Bacon.

Clark, E. V. (1973). Non-linguistic strategies and the acquisition of word meanings. *Cognition*, *2*(2), 161-182. doi: 10.1016/0010-0277(72)90010-8

Clark, E. V. (1983). Meaning and concepts. In P.H. Mussen (Series Ed.), T.H. Flavell & E.M. Markman (Vol. Eds.), *Handbook of child psychology, Vol. 3: Cognitive Development* (787-840). New York: Wiley & Sons.

Cole, E. B., & Flexer, C. (2007). *Children with hearing loss: Developing listening and talking birth to six*. San Diego, CA: Plural Publishing.

Convertino, C., Borgna, G., Marschark, M., & Durkin, A. (2014). Word and world knowledge among deaf learners with and without cochlear implants. *Journal of Deaf Studies and Deaf Education*, *19*(4), 471–483. doi:10.1093/ deafed/enu024

Coyne, M. D., Simmons, D. C., Kame'enui, E. J., & Stoolmiller, M. (2004). Teaching vocabulary during shared storybook readings: An examination of differential effects. *Exceptionality*, *12*(3), 145–162. doi:10.1207/ s15327035ex1203_3

Davis, J. (1974). Performance of young hearing-impaired children on a test of basic concepts. *Journal of Speech, Language, and Hearing Research*, *17*(3), 342-351.

de Villiers, J. G., & de Villiers, P. A. (1978). *Language acquisition.* Boston: Harvard University Press.

Dunn, L. M., & Dunn, D. M. (2007). *Peabody Picture Vocabulary Test* (4th ed.). San Antonio, TX: Pearson Assessments.

Easterbrooks, S. R., & Estes, E. L. (2007). *Helping deaf and hard of hearing students to use spoken language: A guide for educators and families*. Thousand Oaks, CA: Corwin Press.

Engelmann, S., & Carnine, D. (1982). *Theory of instruction: Principles and applications*. Eugene, OR: Irvington Pub.

Fudala, J. B. (2000). *Arizona Articulation Proficiency Scale* (3rd rev.). Los Angeles, CA: Western Psychological Services.

French, L. A., & Nelson, K. (1985). *Young children's knowledge of relational terms: Some ifs, ors, or buts.* New York: Springer-Verlag.

Gast, D. L., & Ledford, J. R. (Eds.). (2009). *Single subject research methodology in behavioral sciences*. New York: Routledge.

Goldman, R., & Fristoe, M. (2000). *Goldman- Fristoe Test of Articulation–2*. Circle Pines, MN: American Guidance Service.

Houston, D. M., Carter, A. K., Pisoni, D. B., Kirk, K. I., & Ying, E. A. (2005). Word learning in children following cochlear implantation. *Volta Review*, *105*, 41–72.

Houston, D. M., Stewart, J., Moberly, A., Hollich, G., & Miyamoto, R. T. (2012). Word learning in deaf children with cochlear implants: Effects of early auditory experience. *Developmental Science*, 15, 448–461. doi:10.1111/j.1467-7687.2012.01140.x

Kaufman, A. S., & Kaufman, N. L. (2004). *Kaufman Brief Intelligence Test* (2nd ed.). San Antonio, TX: Pearson Assessments.

Kirk, K. I., Miyamoto, R. T., Ying, E. A., Perdew, A. E., & Zuganelis, H. (2002). Cochlear implantation in young children: Effects of age of implantation and communication mode. *The Volta Review, 102*, 127–144.

Knoors, H., & Marschark, M. (2014). *Teaching deaf learners: Psychological and developmental foundations*. New York: Oxford University Press.

Kratochwill, T. R., Hitchcock, J., Homer, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M., & Shadish, W. R. (2010). *Single case designs technical documentation*. Retrieved from http://ies.ed.gov/ncee/wwc/pdf/wwc_scd.pdf.

Landry, S. H., & Smith, K. E. (2006). The influence of parenting on emerging literacy skills. In D. Dickinson & S. Neuman (Eds.), *Handbook of early literacy research* (Vol. 2, pp. 135–148). New York: Guilford Press.

Lederberg, A. R. (2003). Expressing meaning: From communicative intent to building a lexicon. In M. Marschark & P. Spencer (Eds.), *Oxford handbook of deaf studies, language, and education* (pp. 247–260). London: Oxford University Press.

Lederberg, A. R., & Spencer, P. E. (2001). Vocabulary development of deaf and hard of hearing children. In M. D. Clark, M. Marschark, & M. Karchmer (Eds.), *Context, cognition, and deafness* (pp. 88–112). Washington, DC: Gallaudet University Press.

Luckner, J. L., & Cooke, C. (2010). A summary of the vocabulary research with students who are deaf or hard of hearing. *American Annals of the Deaf*, *155*(1), 38-67.

Lund, E. (2016). Vocabulary Knowledge of Children With Cochlear Implants: A Meta-Analysis. *Journal of Deaf Studies and Deaf Education*, *21*(2), 107-21. doi: 10.1093/deafed/env060.

Lund, E., & Douglas, W. M. (2016). Teaching Vocabulary to Preschool Children With Hearing Loss. *Exceptional Children, 83*(1), 26-41. doi:10.1177/0014402916651848

Lund, E., Douglas, W. M., & Schuele, C. M. (2015). Semantic Richness and Word Learning in Children with Hearing Loss who are Developing Spoken Language: A Single Case Design Study. *Deafness & Education International, 17*(3). 163-175. doi: 10.1179/1557069X15Y.0000000004

Lund, E., & Schuele, C. M. (2014). Effects of a word-learning training on children with cochlear implants. *Journal of Deaf Studies and Deaf Education, 19*(1), 68-84. doi: 10.1093/deafed/ent036

Marschark, M., & Wauters, L. (2008). Language comprehension and learning by deaf students. In M. Marschark & P. C. Hauser (Eds.), *Deaf cognition: Foundations and outcomes* (pp. 309–350). New York: Oxford University Press.

Marschark, M., Morrison, C., Lukomski, J., Borgna, G., & Convertino, C. (2013). Are deaf students visual learners?. *Learning and individual differences*, *25*, 156-162. doi:10.1016/j.lindif.2013.02.006

Martin, N. A., & Brownell, R. (2010a). *Expressive One Word Picture Vocabulary Test–4*. Novato, CA: Academic Therapy.

Martin, N. A., & Brownell, R. (2010b). *Receptive One Word Picture Vocabulary Test–4*. Novato, CA: Academic Therapy.

Martorella, P. H. (1972). *Concept learning: Designs for instruction.* Scranton, PA: The Haddon Craftsment, Inc.

McGregor, K.K., Sheng, L., & Ball, T. 2007. Complexities of expressive word learning over time. *Language, Speech, and Hearing Services in Schools*, 38:353–64. doi: 10.1044/0161-1461(2007/037)

Massaro, D. W., & Light, J. (2004). Improving the vocabulary of children with hearing loss. *The Volta Review*, *104*(3), 141.

National Governors Association. (2010). *Common core state standards for mathematics*. Washington, DC: Author.

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel: Teaching children to read. An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction* (NIH Publication No. 00-4769). Washington, DC: Government Printing Office. Retrieved from https://www.nichd.nih.gov/publications/pubs/nrp/Pages/ smallbook.aspx

Nash, M., & Donaldson, M. L. (2005). Word learning in children with vocabulary deficits. *Journal of Speech, Language, and Hearing Research*, *48*(2), 439-458. doi:10.1044/1092-4388(2005/030)

Nelson, L. H., Powell, K. L., Bloom, S. E., & Lignugaris/Kraft, B. (2014). Development of basic concepts in early education programs for children who are deaf and hard of hearing using listening and spoken language. *The Volta Review, 114*(1), 7-27.

Nicholas, J. G., & Geers, A. E. (2007). Will they catch up? The role of age at cochlear implantation in the spoken language development of children with severe to profound hearing loss. *Journal of Speech, Language, and Hearing Research*, 50, 1048–1062. doi:10.1044/1092-4388(2007/073)

Nott, P., Cowan, R., Brown, P. M., & Wigglesworth, G. (2009a). Early language development in children with profound hearing loss fitted with a device at a young age: Part I, The time period taken to acquire first words and first word combinations. *Ear and Hearing, 30*(5), 526–540. doi:10.1097/AUD.0b013e3181a9ea14

Nott, P., Cowan, R., Brown, P. M., & Wigglesworth, G. (2009b). Early language development in children with profound hearing loss fitted with a device at a young age: part II—content of the first lexicon. *Ear and Hearing*, *30*(5), 541-551. doi: 10.1097/AUD.0b013e3181aa00ea

Orlikoff, R.F., Schiavetti, N., & Metz, D.E. (2015). *Evaluating Research in Communication Disorders* (7th ed.). Upper Saddle River, NJ: Pearson Education, Inc.

Paatsch, L. E., Blamey, P. J., Sarant, J. Z., & Bow, C. P. (2006). The effects of speech production and vocabulary training on different components of spoken language performance. *Journal of Deaf Studies and Deaf Education*, *11*(1), 39-55. doi: 10.1093/deafed/enj008

Paul, P. V. (2009). *Language and deafness* (4th ed.). Boston, MA: Jones & Bartlett.

Qi, S., & Mitchell, R. E. (2012). Large-scale academic achievement testing of deaf and hard-of-hearing students: Past, present, and future. *Journal of Deaf Studies and Deaf Education*, *17*(1), 1-18. doi: 10.1093/deafed/enr028

Richards, M. (1979). Sorting out what's in a word from what's not: Evaluating Clark's semantic features acquisition theory. *Journal of Experimental Child Psychology*, *27*, 1-47.

Robbins, N. L., & Hatcher, C. W. (1981). The effects of syntax on the reading comprehension of hearing-impaired children. *The Volta Review*, *83*(2), 105-15.

Rose, S., McAnally, P., & Quigley, S. (2004). *Language learning practices with deaf children* (3rd ed.). Austin, TX: Pro-Ed.

Schirmer, B. R. (2000). *Language and literacy development in children who are deaf* (2nd ed.). Boston, MA: Allyn & Bacon.

Simmons, D. C., & Kame'enui, E. J. (1990). *Developing instructional strategies: The prevention of academic learning problems*. Upper Saddle River, NJ: Prentice Hall.

Small, M. (1990). *Cognitive Development.* San Diego: Harcourt Brace Jovanovich.

Stokes, T. F., & Baer, D. M. (1977). An implicit technology of generalization. *Journal of Applied Behavior Analysis*, *10*(2), 349–367. doi: 10.1901/jaba.1977.10-349

Tennyson, R. D., & Cocchiarella, M. J. (1986). An empirically based instructional design theory for teaching concepts. *Review of Educational Research, 56*(1), 40–71.

Trezek, B. J., Wang, Y., & Paul, P. V. (2010). *Reading and deafness: Theory, research, and practice.* Clifton Park, NY: Delmar.

Williams, K. T. (2007). *The Expressive Vocabulary Test* (2nd ed.). Circle Pines, MN: AGS Publishing.

Zimmerman, I. L., Steiner, B. S., & Pond, R. E. (2010). *Preschool Language Scale* (5th ed.). San Antonio, TX: Psychological Corporation.

APPENDICES

Appendix A

Concept Probe Assessment

Spatial

Term	Supplies	Setup	Prompt	Score
Above	1 long block 2 small blocks 1 fish	1. Place the long block on top of the two small blocks to form a bridge. 2. Hand the fish to the child.	"Put the fish above the blocks."	0 1
Across (From)	1 horse 1 girl doll	1. Place the girl doll on the table and say, "Look at the girl." 2. Hand the horse to the child.	"Put the horse across from the girl."	0 1
Ahead	1 turtle 1 fish	1. Place 1 fish and 1 turtle side by side.	"Put the turtle ahead of the fish."	0 1
Apart	2 blocks	1. Hand the child 2 blocks.	"Set the blocks apart on the table."	0 1
Away	1 turtle 1 block	1. Place the block on the table and start "walking" the turtle toward the block. 2. Hand the turtle to the child.	"Make the turtle walk away from the block."	0 1
Back	1 house 1 block	1. Put the house on the table. 2. Hand the block to the child	"Put the block in the back of the house."	0 1
Behind	1 horse 1 block	1. Place the horse on the table facing the child. 2. Hand the child one block.	"Put the block behind the horse."	0 1
Below	1 long block 2 small blocks 1 fish	1. Place the long block on top of the two small blocks to form a bridge. 2. Hand the child 1 fish.	"Put the fish below the bridge."	0 1
Beside	1 block 1 fish	1. Put the fish on the table. 2. Hand the child a block.	"Put the fish beside the block.	0 1
Between	1 horse 2 blocks	1. Place the two blocks on the table. 3. Hand the animal to the child.	"Put the horse between the blocks."	0 1
Bottom	3 different colored blocks	1. Stack two blocks. 2. Hand the child the remaining block.	"Put this block on the bottom."	0 1
Center	1 rope 1 fish	1. Form the rope into a large circle on the table. 2. Hand the child a fish.	"Put the fish in the center of the circle."	0 1
Down	2 blocks 1 turtle	1. Stack two blocks on the table. 2. Put the turtle on top of the blocks.	"Make the turtle go down."	0 1
Edge	1 rope 1 fish	1. Form the rope into a circle on the table. 2. Hand the child the fish.	"Put the fish on the edge of the circle."	0 1
Front	1 fish 1 horse	1. Place the fish on the table. 2. Hand the horse to the child.	"Put the horse in front of the fish."	0 1
High	1 turtle 3 blocks	1. Make a 2-block stack and a 1-block stack. 2. Hand the turtle to the child.	"Put the turtle high on the blocks."	0 1
Left	1 block 1 fish	1. Place one block on the table.	"Put the fish on the left of the block."	0 1
Low	1 turtle 3 blocks	1. Make a 2-block stack and a 1-block stack. 2. Hand the turtle to the child.	"Put the turtle on the low blocks."	0 1
Middle	3 different colored blocks	1. Put two blocks on the table, separated by more than a one-block distance. 2. Hand the child another block.	"Put this block in the middle."	0 1
Near	1 block 1 turtle	1. Put the block on the table. 2. Hand the turtle to the child.	"Put the turtle near the block."	0 1
On	1 block 1 fish	3. Put the block on the table. 4. Hand the fish to the child.	"Put the fish on the block."	0 1
Straight	1 rope	1. Hand the rope to the child.	"Make the rope straight."	0 1
Toward	1 horse 1 block	1. Place the block on the table and start "walking" the horse away from the block. 2. Hand the horse to the child.	"Make the horse walk toward from the block."	0 1

Temporal

Term	Supplies	Setup	Prompt	Score
Always	1 fish 1 horse 1 bowl	1. Place the horse in the bowl. 2. Make the fish jump in and out of the bowl a few times.	"Which animal was always in the bowl?"	0 1
As Soon As	1 fish 1 turtle	Place the fish and turtle on the table within the child's reach.	"Give me the fish as soon as I touch the turtle."	0 1
Day	1 picture of the sun 1 picture of moon	Place pictures on the table.	"Which do we see in the day?"	0 1
During	1 bowl 1 turtle 1 horse	1. Show the child the turtle and bowl, and tell the child, "This turtle is going to take a bath!" 2. Hand the child the horse. 3. Read prompt and then wait about 30 seconds before starting the turtle's bath.	"Put the horse to sleep during the turtle's bath."	0 1
Early	1 pig 1 horse 1 barn Assorted other animals nearby	1. Open the door of the barn. 2. Make the pig walk into the barn. 3. Make the horse walk up to the barn door.	"Who was early?"	0 1
Finish	1 boy doll 1 plate Bread	Give the baby a plate with bread.	"Show me how the boy will finish his bread."	0 1
Late	1 pig 1 horse 1 barn Assorted other animals nearby	1. Open the door of the barn. 2. Make the pig walk into the barn. 3. Make the horse walk up to the barn door.	"Who was late?"	0 1
Leaving	1 pig 1 turtle 1 horse 1 barn	1. Put all the animals in the barn. 2. Make each animal move (e.g., jump or walk). 3. Be sure to touch each animal. 4. Make the horse leave.	"Who was leaving?"	0 1
Morning	Picture of breakfast foods (cereal, eggs, etc)	1. Show child picture.	"Do you eat breakfast in the morning or afternoon?	0 1
Never	1 horse 1 sheep 1 pig 1 barn	1. Place all animals in front of the barn. 2. Make the horse walk into the barn. 3. Make the sheep walk into the barn and then leave. 4. Make the pig jump up and down but not go in the barn.	"Which animal never went to the farm?"	0 1
New	1 old/worn block 1 new block	Place blocks on the table.	"Which block is new?"	0 1
Night	1 picture of the sun 1 picture of the moon	Place pictures on the table.	"Which do we see at night?"	0 1
Old	1 old/worn block 1 new-looking block	Place blocks on the table.	"Which block is old?"	0 1
Start	1 pig 1 turtle 1 horse	1. Line up the animals on the table. 2. Make the horse begin to walk.	"These animals are having a race. Make one of them start."	0 1
Then	1 fish 1 turtle	Place the fish and turtle on the table within the child's reach.	"Give me the fish, then the turtle."	0 1
Today	1 calendar	Point to this week on the calendar.	"Point to today."	0 1
Tomorrow	1 calendar	Point to this week on the calendar. Show the child "today."	"Point to tomorrow."	0 1
While	1 fish 1 turtle	Place the fish and turtle on the table within the child's reach.	"Give me the fish while you give me the turtle."	0 1
Yesterday	1 calendar	Point to this week on the calendar. Show the child "today."	"Point to yesterday"	0 1

Spatial + Temporal (Spatial)

Term	Supplies	Setup	Prompt	Score
After	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Put the turtle after the fish."	0 1
Around	1 rope 1 turtle	1. Put the turtle on the table. 2. Hand the rope to the child.	"Put the rope around the turtle."	0 1
Before	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Put the turtle before the horse."	0 1
Begin	1 turtle 1 fish 1 horse 1 cow	Line up all animals facing the same way, each behind the other.	"Who begins the line?"	0 1
Between	1 fish 2 blocks	1. Place the two blocks on the table. 2. Hand the animals to the child.	"Put the fish between the blocks."	0 1
Close (To)	2 blocks 1 fish	1. Put the fish on the table. 2. Hand the child the blocks.	"Put one block close to the fish."	0 1
Final	1 turtle 1 fish 1 horse 1 cow	Line up all animals facing the same way, each behind the other.	"Who is the final animal?"	0 1
First	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Put the turtle first in this line."	0 1
Fourth	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Put the cow fourth in this line."	0 1
Last	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Put the cow last in this line."	0 1
Next	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Let the cow go next in line."	0 1
Second	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Let the cow be second in this line."	0 1
Third	1 turtle 1 fish 1 horse 1 cow	1. Put the fish and the horse in a line. 2. Hand the other animals to the child.	"Let the cow be third in this line.	0 1
Through	1 long block 2 small blocks 1 fish	1. Place the long block on top of the two small blocks to form a bridge. 2. Hand the fish to the child.	"Make the fish go through the blocks."	0 1

Spatial + Temporal (Temporal)

Term	Supplies	Setup	Prompt	Score
After	1 turtle 1 fish 1 horse	1. Give the animals to the child.	"Give me the fish after you give me the turtle."	0 1
Around	1 rope 1 horse 1 turtle	1. Lay the rope in a line on the table. 2. Put the animals on the rope.	"The horse and turtle are on the rope. Make the horse jump off around the time the turtle jumps off."	0 1
Before	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. Make the horse go before the fish."	0 1
Begin	1 turtle 1 horse 3 pretend strawberries	1. Set the strawberries on the table. 2. Set the animals next to the strawberries.	"The animals are going to eat. The turtle can begin. Show me."	0 1
Between	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Make the fish, then the horse jump into the bowl (pause for a long time – 30+ seconds- between the two). 3. Say prompt, then repeat step 2.	"This time, make the lion jump in the bowl between the horse and the fish."	0 1
Close (To)	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Make the fish, then the horse jump into the bowl (pause for a long time – 30+ seconds- between the two). 3. Say prompt, then repeat step 2.	"This time, make the lion jump in the bowl close to the time the fish jumps in the bowl."	0 1
Final	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. Make the horse the final jumper."	0 1
First	**1 lion 1 fish 1 horse 1 bowl**	**1. Set the bowl on the table. 2. Hand the animals to the child.**	**"The lion, fish and horse are going to jump into the bowl. The fish will go second. Make the lion go first."**	**0 1**
Fourth	1 lion 1 fish 1 horse 1 pig 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish, pig and horse are going to jump into the bowl. The lion will go second. Make the pig go fourth."	0 1
Last	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. The fish will go second. Make the lion go last."	0 1
Next	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. The fish will go first. Make the horse go next."	0 1
Second	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. The fish will go second. Make the lion go last."	0 1
Third	1 lion 1 fish 1 horse 1 bowl	1. Set the bowl on the table. 2. Hand the animals to the child.	"The lion, fish and horse are going to jump into the bowl. The fish will go second. Make the lion go third."	0 1
Through	3 child figures 3 plates 6 pretend strawberries	1. Give 1 child figure an empty plate. 2. Give 1 child figure a full plate. 3. Give 1 child figure an almost empty plate.	"Who is through?"	0 1

Appendix B

Example Score Sheet

Date	Taught Concept		Student A	Student B	Untaught Concept		Student A	Student B
7/11	BOX 1 Spatial	above			BOX 3 Spatial Temporal (Temporal Meaning)	after		
		back				begin		
		below				between		
		edge				final		
		near				through		
		SCORE				SCORE		

Appendix C

Treatment Fidelity Checklist

Teacher Name: Fidelity transcriber:

Children (codes) present: Date:

Step	Completed?
Set-up	
Children are able to view the teacher without obstruction	/1
Children begin the lesson attentive to the teacher	/1
Teacher indicates the purpose of the lesson (e.g., today we are going to talk about new words)	/1
For introduction of each word:	
Teacher isolates concept by introducing one concept at a time	/5
Teacher says new word	/5
Teacher asks children to imitate new word	/5
Teacher gives 5 positive examples of word for each word	/5
Teacher gives 5 negative examples of word for each word	/5
Teacher moves between positive/negative example at least 3 times for each word	/5
Teacher uses at least 3 different contexts for examples for each word (e.g., if word is “under,” teacher shows under chair, under table, under box)	/5
Teacher begins with most obvious examples and moves to more abstract examples (e.g., start with “under” table before introducing “under” a window)	/5
For receptive practice with each word:	
Teacher hands child an object or picture and asks the child to demonstrate the concept	/5
For expressive practice with each word:	
Teacher asks each child to use the word productively in an obligatory context: (e.g., oh look, where is the dog?)	/5