

A QUALITATIVE RETROSPECTIVE STUDY OF MULTIPLE OPPOSITIONS
AS AN INTERVENTION OPTION FOR CHILDREN
WHO ARE MODERATELY TO SEVERELY UNINTELLIGIBLE

by

Rachelle Ronshaugen

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Texas Christian University
Fort Worth, Texas

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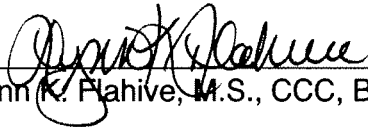
A Thesis for the Degree

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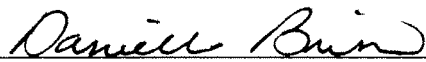
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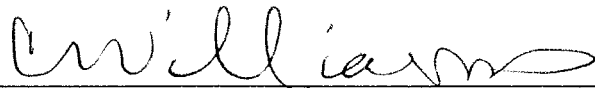
Lynn K. Flahive, M.S., CCC, BCS-CL, Major Professor



Christopher R. Watts, Ph.D., CCC, Committee Member



Danielle Brimo, Ph.D., CCC, Committee Member



Cynthia Williams, Ph.D., Committee Member



Dr. Debbie Rhea, Associate Dean
Harris College of Nursing & Health Sciences

May 2016

Abstract

The purpose of this study was to address the following questions about children who are moderately to severely unintelligible subsequent to a semester of treatment in multiple oppositions therapy: (1) Do the *trained* collapses in their phonetic inventories shrink; (2) Do the *untrained* collapses in their phonetic inventories shrink, as demonstrated by (a) generalization beyond targeted positions to other positions of sounds in words and/or (b) generalization beyond targeted sounds/features to other sounds/features in their phonetic inventories? Retrospective clinical data was used to conduct a study including a detailed analysis of gathered clinical data on four participants. Following one semester of multiple oppositions intervention, trained and untrained collapses in all participants' phonetic inventories shrunk. Participants also demonstrated positional and sound generalization to untrained sounds. In addition, improvements on trained and untrained probes from pre-treatment to post-treatment further validate a multiple oppositions approach to intervention for highly unintelligible children.

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TABLE OF CONTENTS

Approval Page.....	i
Abstract.....	ii
Acknowledgements.....	iii
List of Figures.....	v
List of Tables.....	vi
Introduction.....	1
Review & Purpose.....	11
Methodology.....	13
Results & Discussion.....	22
References.....	59
Appendices.....	37

LIST OF FIGURES

<i>Figure 1.</i> Example of a phonological collapse.....	3
<i>Figure 2.</i> Equation for percentage target consonants correct.....	21
<i>Figure 3.</i> Results all participants trained probe words.....	32
<i>Figure 4.</i> Results all participants untrained probe words.....	33

LIST OF TABLES

<i>Table 1.</i> Collapses for Participant 1.....	17
<i>Table 2.</i> Collapses for Participant 2.....	17
<i>Table 3.</i> Collapses for Participant 3.....	18
<i>Table 4.</i> Collapses for Participant 4.1.....	18
<i>Table 5.</i> Collapses for Participant 4.2.....	18
<i>Table 6.</i> Summary Trained Collapses Shrinkage for all Participants.....	22
<i>Table 7.</i> Results all participants trained probe words.....	31
<i>Table 8.</i> Results all participants untrained probe words.....	32
<i>Table A1.</i> Description of participants.....	37
<i>Table C1.</i> Probe Results Participant 1.....	39
<i>Table C2.</i> Probe Results Participant 2.....	40
<i>Table C3.</i> Probe Results Participant 3.....	42
<i>Table C4.</i> Probe Results Participant 4.1.....	44
<i>Table C5.</i> Probe Results Participant 4.2.....	46
<i>Table D1.</i> Complete Collapse Results Participant 1.....	48
<i>Table D2.</i> Complete Collapse Results Participant 2.....	50

<i>Table D3. Complete Collapse Results Participant 3.....</i>	<i>52</i>
<i>Table D4. Complete Collapse Results Participant 4.1.....</i>	<i>54</i>
<i>Table D5. Complete Collapse Results Participant 4.2.....</i>	<i>56</i>

INTRODUCTION

Disordered Phonology

Phonology has been described as a code in which sequences of sounds come together to form words that represent abstract concepts (Dodd, Crosbie, McIntosh, Holm, Harvey, Lidy, Fontyne, Pinchin, and Rigby, 2008). Cognitive-linguistic processing is required to contrast sounds and mark consonant position, and then to use the phonological system *consistently* (Dodd et al., 2008). Dodd et al (2008) state that, “children referred with limited speech intelligibility of no known origin are diagnosed as having a phonological disorder” (p. 335). A systematic review by Law et al. (2000) found that between 2% to 25% of children ages 5 to 7 may have a speech sound disorder (ASHA, n.d.). It is important that speech-language pathologists select an appropriate intervention approach to deliver effective and efficient treatment as possible. Currently, there is much debate as to which phonological intervention will achieve this goal. Multiple oppositions is an intervention option for children with moderate to severe phonological disorders proposed by Williams (2010), and it is believed to achieve “the greatest amount of change in the least amount of time” (Williams, 2000a, p. 297). The current study investigated whether a multiple oppositions approach to intervention improves preschool to school-age children’s speech intelligibility.

Current Intervention Options

Fey (1986) explains that there are three main goal attack strategies to remediate speech sound disorders. There are *vertical goal attack strategies*, which target *one to two* sounds at a time until a mastery criterion has been met (Bernthal, Bankson, & Flipsen, 2013; Fey, 1986; Gierut, 2001; Williams, 2005). There are *horizontal goal attack strategies*, which target *several* sounds or patterns in a sequence (Bernthal et al., 2013; Gierut, 2001; Williams, 2005). There are also *cyclically structured treatment programs*, such as Hodson's phonological cycles approach (Bernthal et al., 2013). It combines the vertical and horizontal strategies by addressing a single target or pattern for a set amount of time before moving on to the next. The child moves from goal to goal as the treatment cycle progresses (Bernthal et al., 2013). Since the creation of Hodson's approach, even newer approaches have come about which contrast the sounds the child already has in his or her inventory with those he/she is lacking. One cyclical approach is a multiple opposition approach to intervention (Williams, 2010).

Multiple Oppositions Intervention: Overview

The goal of many phonological approaches to intervention is to re-organize a child's linguistic system by eliminating deviant rules and processes, such as fronting or gliding (Dodd et al., 2008; Grunwell, 1983). Williams advocates for seeing each child not just as having a series of phonological patterns, rather, as having a unique, independent system (Williams, personal communication, October 28, 2015). This leads to a more holistic approach to intervention, as opposed to viewing the child's sound system in fragments (Williams, personal communication, October 28, 2015).

The ultimate goal is to reduce the size of the child's entire phonological breakdown (Williams, 2000b). If a multiple oppositions approach could reduce the size of a child's collapses, it would directly reduce homonymy, and as a result, improve a child's speech intelligibility.

Williams (2003) explains that in adult speech, each target sound has a unique production. For example, the phoneme /d/ is produced in a specific way, different than the phoneme /s/. If you were to produce the word "sill" but replace the phoneme /s/ with /d/, the word "dill" would result. We understand these words to sound different and mean different things. According to Williams (2003), a child with a disordered speech sound system may collapse several phonemes into a single sound. A child may produce the phoneme /d/ for the phonemes /s, sk, dr, tʃ/. This is considered to be a *collapse*, in which five different phonemes (/d, s, sk, dr, tʃ/) have collapsed into one (/d/). It would be diagrammed as follows:



Figure 1. Example of a phonological collapse.

Based on the collapse above, the child would produce "dill," "skill," "drill," "chill," and "sill," as "dill." A therapy session following a multiple oppositions approach to inter-

vention may feature the errored production "dill" and the new targets "skill," "drill," "chill," and "sill."

Williams (2015) explains that children with limited phonetic inventories "have to take their smaller number of sounds that they produce and stretch it across all of the adult's sounds. This results in a one [sound] to many [sounds] correspondence between the child's and adult's systems" (personal communication, October 28, 2015). The result is homonymy, wherein the child replaces several sounds with one sound, leading to significant unintelligibility when attempting to communicate (Williams, 2000b; 2010). These children follow specific phonological rules that they have created to compensate for sounds absent in their inventories. Despite having a sound system that is considered "disordered" when compared to the adult inventory, the child's sound system becomes its own "native language" (Williams, personal communication, October 28, 2015). Grunwell (1997) describes this as the "order in disorder" (p. 61).

Multiple Oppositions Intervention: Theoretical Basis

Multiple oppositions therapy is based on three primary principles: (a) contrastive elements provide meaning; (b) targets across a large rule set are selected to attain these contrastive elements; and as a result (c) generalization should occur (Gierut, 2001; Grunwell, 1997; Williams, 2010).

(a) Contrastive Elements. According to Grunwell (1997), the contrastive elements of language, such as the initial phonemes in words mentioned earlier, are what make it meaningful. Meaning is lost for the listener when these contrastive elements disappear, as is the case with children with speech sound disorders. A multiple oppositions approach to therapy directly addresses the disappearance of these contrastive elements (Williams, 2010). It provides the child with a range of diverse new contrasts to facilitate in decreasing the child's homonymy (Williams, 2010).

(b) Target Selection. Gierut (2001) explains that speech-language pathologists often choose therapy targets based on three clinical factors: "consistency of error, normative age of acquisition, and number of errors to be treated" (p. 230). Williams argues for an approach in which target selection is based on *diversity* and the *functionality* of sounds within a child's unique phonological system (Gierut, 1990a; 1990b; Williams, 2005). Her approach is founded on two parameters: maximal classification and maximal distinction (Gierut, 1990a; 1990b; Williams, 2003; 2005; 2006). Maximal classification refers to target sounds being chosen that differ in terms of place, manner, and voicing of production. Similarly, maximal distinction, a term described by Gierut (1990a), refers to targets being maximally distinct from the child's error *within the collapse* in terms of place, manner, and voicing. Williams (2000a; 2005; 2006; 2010) states that when targets are maximally distinct from error patterns and maximally classified within a collapse, they are more salient and

therefore more learnable (as cited by Gierut, 1990a; 199b). This is in line with Gierut's (2001) claim that, "treatment of more complex properties of the phonological system appears to result in the greatest generalization and change" (p. 230).

A multiple oppositions approach targets substitution errors and syllable structure errors including consonant and vowel substitutions in all positions, cluster reduction, word-initial deletion, and word-final deletion (Williams, 2010).

Williams states that "you want to get the greatest phonetic distance across each of the target sounds that you're teaching so that you're teaching different places, different manners, different voicing, and different linguistic units" (Personal communication, October 28, 2015). Williams calls this "enlarging the frame of learning" (Personal communication, October 28, 2015).

Following the principles of maximal classification and maximal distinction, two to four target sounds are chosen from one rule set (Williams, 2006; 2010).

The two to four targets chosen within the collapse represent one phonological goal (Williams, 2005). So, a semester of intervention for a child may target three collapses, with four targets in each collapse.

(c) Generalization. Gierut (2001) claims that the ultimate goal in target selection is to induce the greatest amount of generalization, or transfer of learning, of the child's sound system. Local generalization occurs when "the phonological property being treated is precisely that which improves" (Gierut, 2001,

p. 230). For example, if the child has been training on /t/ at the initial position of words, it may generalize to /t/ in the final position of words. Generalization may be within-class, in that the trained sound may impact untrained sounds within the same class (Gierut, 2001). If a child is trained on the stop /t/, it may generalize within-class to the stop /p/. On the other hand, generalization may be across-class, in that the trained sound may impact untrained sounds within a different class (Gierut, 2001). Training of the stop /t/, may generalize to production of the affricate /tʃ/. According to the principles of the complexity theory, because multiple oppositions targets many sounds at once, it is predicted to generalize to other sounds within the same collapse and even to the collapses that are not targeted in therapy (Gierut, 2001).

Multiple Oppositions Intervention: Exploratory Studies

Williams (2010) describes a series of published and unpublished exploratory studies that have been conducted on the effectiveness of multiple oppositions therapy in regard to resolving disordered phonology.

A paper presented by Cathell and Ruscello (2004) provides a description of a 4;0 girl with severe phonological impairment. Following twenty-four multiple opposition intervention sessions the child expanded her consonant inventory, resulting in the “reduction of the 1:34 phoneme collapse of word-initial consonant deletion of a 1:7 phoneme collapse, with phonological restructuring” (as cited by Williams, 2010, p. 79).

An exploratory study by Marcum & Williams (2005) investigated the use of multiple oppositions with a 5;5 child with co-morbid speech sound disorder and expressive language impairment. Following twenty-one multiple opposition intervention sessions, the child's 1:16 phoneme collapse was eliminated (Marcum & Williams, 2005; as cited by Williams, 2010).

An exploratory study by Liles & Williams (2006) investigated the use of multiple oppositions with a 5;5 child with a mixed phonetic-phonemic speech disorder. Following multiple opposition intervention, the child decreased from 44 errors to 25 errors (Liles & Williams, 2006; as cited by Williams, 2010).

Although positive outcomes of multiple oppositions intervention have been reported, Williams (2010) admits that the studies do not "provide empirical validation of the effectiveness of the multiple oppositions approach" (p. 80). A majority of these studies are limited to unpublished papers and posters presented or case studies; however, they do demonstrate replication of treatment effects across different children in different settings (Williams, 2010).

Multiple Oppositions Intervention: Efficacy Studies

Williams and Kalbfleisch (2001) conducted a single-subject design of multiple baselines across subjects and behaviors with fourteen children with moderate-to-severe phonological disorders placed in treatment or delayed-treatment groups. The majori-

ty of sounds targeted showed significant improvement and “systemwide phonological change was observed as the PKK significantly increased from a mean of 38.7% (pretreatment) to a mean of 62.5% (posttreatment)” (Williams & Kalbfleisch, 2001; as cited by Williams, 2010, p.80).

A study conducted in Brazil by Paglairin (2009) investigated treatment outcomes across minimal pairs, maximal oppositions with two target sounds, and multiple oppositions with children with varying degrees of disordered phonology severity. All three approaches were found to be effective, however for children who had moderate-to-severe and severe phonological impairment, “multiple oppositions resulted in greater phonemic changes as indicated by the largest acquisition of phonemes in the phonological system and the establishment of more distinctive features” (Paglairin, 2009; as cited by Williams, 2010, p.82). Williams stated that she believes that there is power in a study demonstrating the effectiveness of intervention in another language (Williams, personal communication, October 28, 2015).

Multiple Oppositions Intervention: Population

Williams admits that there is not one phonological approach that will work best for every child (Personal communication, October 28, 2015). Williams (2010) states that multiple oppositions is a treatment approach that should be used primarily with: (a) “children who have multiple sound errors that originate from a nonorganic basis” (p.74), who would be considered to have moderate to severe phonological

disorders (Williams, 2000a; 2010), and (b) children with unusual or idiosyncratic errors (Williams, Personal communication, October 28, 2015).

(a) Moderate-severe phonological disorders. Williams (2000a) argues that children who have moderate to severe phonological disorders are more likely to have extensive phoneme collapses, requiring more system-wide restructuring. She argues that a multiple opposition approach has the potential to allow children to “make connections about their phonological structure strategies with what needs to be learned and then revise their strategies based on the confrontation of the new and focused phonologic information” (Williams, 2000a, p.290).

(b) Unusual/ idiosyncratic errors. Additionally, because multiple oppositions is an individualized approach that directly addresses each child’s unique phonological system, it would make sense that it benefits children with idiosyncratic errors (Williams, 2000a; Personal communication, October 28, 2015). Defining these children with predetermined categories, such as the phonological patterns mentioned previously, may prove challenging or it might miss the unique aspects of their sound systems. Multiple oppositions would allow for a more holistic understanding and targeting of the participants’ sound systems (Williams, Personal communication, October 28, 2015).

Multiple Oppositions Intervention: Intervention Sequence

A longitudinal study by Williams (2000a) followed ten, 4-5;6 year-old moderate-to-profound phonologically impaired children through three different interventions to address their phonological systems: naturalistic speech intelligibility intervention (NSI), minimal pairs, and multiple oppositions. All ten of the children started with multiple oppositions therapy whereas five continued on to NSI and six continued on to minimal pair therapy. Although there was no significance between severity level and progression of intervention model, it was found that the more profound children required greater intervention diversity, probably because they needed complete restructuring of their sound systems. Additionally, Williams (2000a) concluded that a child's intervention needs should not be seen as permanent, rather reassessed throughout the course of intervention. In fact, Williams has suggested that a young child start with a play-based approach before engaging in a more structured approach, such as multiple oppositions. As the child matures, a multiple oppositions approach may be used to produce a large change across their sound system. Finally, the child may end with a more focused approach, such as a minimal pairs, to "fine tune" their remaining speech sound errors (Williams, Personal communication, October 28, 2015).

Review & Purpose

Although speech language pathologists have used multiple oppositions intervention for several years, there is limited literature on the effectiveness of this therapy option. Supporting evidence is limited to non-experimental case studies and unpub-

lished research. Additionally, most of the current research is from Williams and she also recognizes the need for others to conduct studies to support her findings. A reliable study is needed to prove successful outcome measures following treatment.

This study uses retrospective data to address the following questions about children who are moderate to severely unintelligible subsequent to a semester of treatment in multiple oppositions therapy: (1) Do the *trained* collapses in their phonetic inventories shrink; (2) Do the *untrained* collapses in their phonetic inventories shrink, as demonstrated by (a) generalization beyond targeted positions to other positions of sounds in words and/or (b) generalization beyond targeted sound features (place/manner/voicing) to other sounds in their phonetic inventories?

It was expected that the number of collapses in the participant's phonetic inventories would shrink following a semester of treatment in multiple oppositions therapy. In other words, the number of sounds a child produces as a single sound should decrease. This would be determined by comparing each participant's phonetic inventories and phoneme collapses prior to and following a semester of treatment in multiple oppositions therapy. Percentage of words correct from a probe list would also increase upon each administration throughout the semester. Lastly, it was expected that there would be generalization beyond targeted sound features and positions to other sounds and position of sounds in words in the participants' phonetic inventories.

METHODOLOGY

Research Design

Retrospective clinical data was used to conduct a study including a detailed analysis of clinical data on four participants (data on participant 4 data was collected over two separate semesters, as indicated by 4.1 and 4.2 from here on out).

Participants, Recruitment, & Criteria

Clinical information on four monolingual English-speaking children from the Miller Speech and Hearing Clinic (MSHC) at Texas Christian University (TCU) was organized and described. All four participants were classified as being moderate to severely unintelligible as determined by the clinician and supervisor. Based on William's previous research, additional participation criteria included being between the ages of 3;0-7;0, exclusion of at least six sounds in error across three different manner classes of sound production as determined by a phonological analyses, hearing that is within normal limits given a hearing screening conducted for the frequencies 500, 1000, 2000, and 4000 Hz at intensity of 20dBHL, and no pre-existing conditions as determined by a case history review. See Appendix A for a participant description summary.

Participant Summary

Participant 1

Participant 1 began treatment at age 3;8. He had received language therapy from Early Childhood Intervention (ECI) when he was 22 months old. He also

received two semesters of therapy at MSHC clinic prior to multiple oppositions intervention. Previous therapy focused on increasing producing of consonants, improving syllable awareness, requesting using verbalization, as well as producing multisyllabic words, initial /s/ clusters, and final velars. Participant 1 received 26, 30-minute session, totaling 13 hours of multiple oppositions intervention.

Participant 2

Participant 2 began treatment at age 3; 10. She received one semester of therapy at MSHC clinic prior to multiple oppositions intervention. Previous therapy was conducted via Skype and followed Hodson's cycles approach to phonological therapy. Therapy focused on production of initial /s/ clusters, initial velars /k,g/, and initial stridents /s, z, f, v, tʃ, ʃ/.

Participant 2 received 11, 60-minute session, totaling 11 hours of intervention. It should be noted that participant 2 made such excellent progress she moved to minimal pair intervention after 4 weeks of multiple oppositions intervention. As noted previously, Williams states that a more structured approach may be used to "fine tune" remaining speech sound errors following multiple oppositions (Williams, Personal communication, October 28, 2015). In addition, a portion of therapy focused on correct production of the pronoun "she" through structured language therapy and informal play therapy.

Participant 3

Participant 3 began treatment at age 6;5. He received three consecutive semesters of therapy at MSHC, took one year off from MSHC, and returned for 3 more semesters, totaling six semesters of therapy prior to multiple oppositions intervention. Previous targets included production of /s/ clusters, /sm, sn, sp, st/, velars, /k, g/, and stridents, /s,f/. Participant 3 received 21, 30-minute sessions, totaling 10.5 hours of multiple opposition intervention.

Participant 4.1

Participant 4.1 began treatment at age 6;0. He received four semesters of individual therapy at MSHC clinic prior to multiple oppositions intervention. Therapy focused on /s/ clusters, stridents, velars, /r/, final plural clusters, and auxiliary verb phrases. Additionally, participant 4.1 participated in weekly classroom intervention with an emphasis on phonological awareness. Participant 4.1 received 20, 30-minute sessions, totaling 10 hours of multiple opposition intervention.

Participant 4.2

Participant 4.2 began another semester of multiple oppositions treatment at age 6;9. He received one semester of multiple oppositions intervention during his most recent semester at MSHC (see participant 4.1). He received five semesters of therapy at MSHC prior to multiple oppositions intervention. Therapy focused on /s/ clusters, stridents, velars, /r/, final plural clusters, and

auxiliary verb phrases. Participant 4.2 received 10, 60-minute sessions, totaling 10 hours of multiple opposition intervention.

Setting

All participants received individual intervention for one hour each week, for 12 weeks during either the Spring 2015 or Fall 2015 semester. Treatment for all participants, except Participant 2, took place at MSHC, a private clinic located on the campus of Texas Christian University (TCU). Participant 2 received intervention via Skype. The participant's mother was present at all times during Skype delivered intervention. The clinician conducted the session in a small room with her clinical supervisor present. Either an undergraduate or graduate student clinician provided intervention for all participants in this study. For the participants treated at the MSHC, each session was conducted in a small therapy room equipped with two chairs that faced each other across a small wooden table. The participant sat approximately three feet across from the clinician during the entire session, except for when the participant was engaged in an activity that required moving around the therapy room. The therapy room contained few, if any, audio and visual distractions. The room was also equipped with a large wall-mounted white board and a one-way mirror for supervisor and parent observation. The door was kept closed during the entirety of every session.

Procedures

Pre-Treatment Procedures

Prior to multiple opposition intervention, the Single Words from PACC (Baker) list was administered to each child. It is made up of 136 words including the phonemes /p, b, t, d, k, g, n, ŋ, f, v, s, z, ʃ, ʒ, θ, ð, tʃ, dʒ, w, j, l, r, h/ in all possible positions and cluster combinations. Each child's case history was reviewed to confirm there were no pre-existing conditions that would exclude the child from the study, and to confirm that the child had normal hearing.

Based on results from the Single Words from PACC (Baker) list, collapses were mapped for each participant. Between 2 to 4 rule-sets, or collapses, were chosen for each participant. Each collapse contained 1 to 12 errored productions. Collapses were chosen based on the principles of maximal classification and maximal distinction (Gierut, 1990a; 1990b; Williams, 2003; 2005; 2006). *Tables 1-5* display the collapses chosen for each participant.

Table 1. Collapses for Participant 1.

Production	Initial	Medial	Final
Omission	/k, w, s, b/	/l, t, dʒ/	
/k/	/d, t, p/		
/d/	/tʃ/		

Table 2. Collapses for Participant 2.

Production	Initial	Medial	Final
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Omission /s/ + Consonant	/sk, sl, sn, sp, sm/		
/s/			/st, sk, ts/

Table 3. Collapses for Participant 3.

Production	Initial	Medial	Final
Omission			/k, r, g, d/
/d/	/sk, k, b, g, tr, t, f, v, s, ʃ, ʃr, dʒ/		
/w/	/ð, θ, l, r, gl, dr, sl, sw, kl/		

Table 4. Collapses for Participant 4.1

Production	Initial	Medial	Final
/d/	/s, z, θ, dʒ, sk, dr, tr/		
Omission	/tʃ, dʒ, sp, mj, fj/		/d, tʃ, s, dʒ, st, sk, ts, ft/

Table 5. Collapses for Participant 4.2

Production	Initial	Medial	Final
/d/	/s, z, dʒ, sk, θ, tr, sk, skr, st/		
Omission			/d, s, z, p, t/

Treatment Structure

Participants received either two 30-minute sessions or one 60-minute session each week throughout the semester. Each session followed the same structure

across all clients. For the 30-minute sessions, every two sessions targeted the same collapse, addressing different errors through word sets within each collapse. The following two sessions targeted a different collapse, and so on. Each 60-minute session targeted one collapse, with the following session targeting a different collapse, with reversal to the initial collapse in the subsequent session, and so on.

One half of each session featured words taught through a story presentation. The other half of each session featured a set of words trained through a drill-based, more natural activity. Before engaging in either the story presentation or drill-based activity, the word set was reviewed with the client. See Appendix B for example of a timeline of a session and materials used.

Each client had a different clinician, who was either an undergraduate student or first-year graduate student. All of the students who implemented therapy were trained in multiple opposition intervention by a clinical supervisor and at least 35% of their sessions were observed by the same clinical supervisor.

It should be noted that in addition to receiving individual multiple opposition intervention, some participants participated in a twice-weekly classroom program that focused on phonological awareness and language therapy.

Administration of Probe Testing

For 30-minute sessions, a list of 20 trained and 20 untrained stimuli was presented during the first 5 minutes of every 4th session of treatment. For 60-minute sessions, the list was presented during the second half of every other session. Word lists were generated based on client collapses. All clients participating in multiple oppositions therapy during each semester had the same list of untrained words. These words addressed each child's collapses at least once. Untrained words were never targeted during intervention. Each client had a different set of trained words specific to their individual collapses. All trained words were targeted in intervention multiple times throughout the semester. See Appendix C for complete probe lists and results. Only target phonemes were included in probe results. Approximations, such as lateralization of /s/, were not counted as correct.

Post-Treatment Procedures

During the last week of intervention the Single Words from PACC (Baker) list was re-administered to determine change in collapse size for each client.

Data Analyses

Along with descriptive data, two primary measures were collected for each client. First, improvement based on intervention being applied was determined via probe measures recorded every hour and a half of intervention. The second measure was determined by comparing collapse size pre- and post- treatment.

The measure of the shrinkage of the participants' phonological collapses was determined by comparing collapse size pre and post treatment. For example, if a participant started with a 1:6 collapse prior to treatment, and ended with a 1:0 collapse, the collapse shrunk by 100%, or completely disappeared. If the client's 1:6 collapse turned into a 1:3 collapse, the collapse shrunk by 50%.

A more general measure of overall shrinkage of the participants' phonological collapses was determined by the calculation of percentage target consonants correct (see *Figure 2*) on probe lists administered throughout the twelve-week treatment phase.

target consonants correct

total target consonants X 100

Figure 2. Equation for percentage target consonants correct

Reliability

A graduate student uninformed about the study but trained in calculation of ratio of shrinkage and percent shrinkage measures, re-measured 100% of targeted collapse data for all participants. Upon re-measuring, data was found to be 93% reliable for both ratio of shrinkage and percent shrinkage measures.

RESULTS & DISCUSSION

1) Do the trained collapses in the participants' phonetic inventories shrink?

Table 6 summarizes the ratio of shrinkage and percent shrinkage for trained collapses pre- and post- treatment.

Table 6. Summary Trained Collapses Shrinkage for all Participants

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
Participant 1								
Omission	/k, w, s, b/		/l, t, dʒ/	/t/			l: 1:4 to 1:0 M: 1:3 to 1:1	l: 100% M: 67%
/k/	/d, t, p/						l: 1:3 to 1:0	l: 100%
/d/	/tʃ/						l: 1:1 to 1:0	l: 100%
Participant 2								
Omission /s/ + Consonant	/sk, sl, sn, sp, sm/	/sn/					l: 1:5 to 1:1	l: 80%
/s/					/st, sk, ts/		F: 1:3 to 1:0	F: 100%
Participant 3								
Omission					/k, r, g, d/	/k, r, g, d/	F: 1:4 to 1:4	F: 0%
/d/	/sk, k, b, g, tr, t, f, v, s, ʃ, ʃr, dʒ/	/b, v, g, st, tʃ/					l: 1:12 to 1:5	l: 58%

/w/	/ð, θ, l, r, gl, dr, sl, sw, kl/	/l, r/					I: 1:9 to 1:2	I: 78%
Participant 4.1								
/d/	/s, z, θ, dʒ, sk, dr, tr/	/s, f, θ, ð, dʒ, sk, str/ tr/					I: 1:7 to 1:7	I: 0%
Omission	/tʃ, dʒ, sp, mj, fj/	/dʒ, j, sp/			/d, tʃ, s, dʒ, st, sk, ts, ft/	/s, θ, ft/	I: 1:5 to 1:3 F: 1:8 to 1:3	I: 40% F: 63%
Participant 4.2								
/d/	/s, z, dʒ, sk, θ, tr, sk, skr, st/	/s, sk, st, skr/					I: 1:9 to 1:4	I: 56%
Omission					/d, s, z, p, t/	/s, z/	F: 1:5 to 1:2	F: 60%

Participant 1

Participant 1's initial omission collapse (Omission for /k, w, s, b/ indicates a 1:4 collapse) completely disappeared (1:0 indicates complete disappearance of the collapse). His medial omission collapse (1:3) shrunk to 1:1, demonstrating a 67% shrinkage. His initial /k/ collapse (1:3) completely disappeared (1:0), along with his initial /d/ collapse (1:1) to (1:0). Three out of four targeted collapses completely disappeared following one semester of multiple oppositions intervention.

Participant 2

Participant 2's omission of initial /s/ + consonant collapse shrunk from 1:5 to 1:1, demonstrating an 80% shrinkage. Her final /s/ collapse (1:3) completely disappeared. One out of two targeted collapses completely disappeared following one semester of multiple oppositions and minimal pairs intervention.

Participant 3

Participant 3's final omission collapse (1:4) did not change (1:4). His initial /d/ collapse (1:12) shrunk (1:5), demonstrating a 58% shrinkage, along with his initial /w/ collapse (1:9) which shrunk to 1:2, demonstrating a 78% shrinkage. Out of four total collapses, one collapse completely disappeared, two shrunk, and one remained the same.

Participant 4.1

Participant 4.1's initial /d/ collapse (1:7) remained the same. His initial omission collapse (1:5) shrunk to 1:3, demonstrating a 40% shrinkage. Additionally, his final omission collapse (1:8) shrunk to 1:3, demonstrating a 63% shrinkage. Although none of Participant 4.1's collapses disappeared completely, two of his three targeted collapses shrunk following a semester of multiple oppositions intervention.

Participant 4.2

Participant 4.2's initial /d/ collapse shrunk from 1:9 to 1:4, demonstrating a 56% shrinkage. His final omission collapse shrunk from 1:5 to 1:2, demonstrating a 60% shrinkage. Following one semester of multiple oppositions intervention, both of Participant 4.2's collapse shrunk.

Summary

All participants demonstrated shrinkage of trained collapses following one semester of MO intervention. Only two of the collapses did not change. The remaining collapses shrunk between 40-100%. Several of the collapses disappeared altogether, reprinting a 100% shrinkage.

2) Do the untrained collapses in the participants' phonetic inventories shrink, as demonstrated by positional and/or sound feature generalization?

Participant 1

Participant 1 demonstrated generalization of multiple oppositions intervention across untargeted phonemes and phoneme placement (initial, medial, final) within targeted collapses. Although only four phonemes were targeted for his initial omission collapse, his 1:12 collapse completely disappeared to 1:0.

This demonstrates generalization to untargeted phonemes within the targeted collapse. Only participant 1's initial and medial omission collapses were tar-

geted over the course of the semester, but his final omission collapse also shrunk from 1:3 to 1:1.

Despite having targeted only one phoneme for his initial /d/ collapse, /tʃ/, which disappeared following multiple oppositions intervention, participant 1's initial /d/ collapse shrunk from 1:5 to 1:2. Additionally, his medial /d/ collapse shrunk from 1:3 to 1:1.

Participant 1 also demonstrated generalization of multiple oppositions intervention across untargeted collapses. Notable shrinking of collapses included initial bilabials /b/ and /p/, which shrunk from 1:5 to 1:1 and 1:4 to 1:1, respectively. His initial /w/ collapse shrunk from 1:9 to 1:4. Several 1:1 collapses disappeared including initial and medial /m/, medial /j/, medial /θ/, final /ʃ/, and initial /bw/.

Participant 2

Participant 2 demonstrated generalization of multiple oppositions intervention across untargeted phonemes and phoneme placement (initial, medial, final) within targeted collapses. Although only five clusters were targeted for her initial omission /s/ + consonant collapse, her 1:8 collapse shrunk to 1:1. Her final omission /s/ + consonant collapse shrunk from 1:2 to 1:1. Although only three phonemes/clusters were targeted for her final /s/ collapse, her 1:4 completely disappeared to 1:0. Additionally, her initial /s/ collapse disappeared

from 1:1 to 1:0. The shrinkage of the collapses beyond the targeted phonemes demonstrates generalization to untargeted phonemes within the targeted collapse.

Participant 2 also demonstrated generalization of multiple oppositions intervention across untargeted collapses. Notable shrinking of collapses include initial, medial, and final omission collapses, which shrunk from 1:1 to 1:0, 1:3 to 1:0, and 1:3 to 1:1, respectively. Initial /w/ collapse shrunk from 1:5 to 1:1. Several 1:1 collapses disappeared, including, initial /t/, final /l/, initial and final /b/, medial and final /tʃ/, medial /dʒ/, initial /ʒ/. Several 1:1 cluster collapses disappeared, including initial /st/, /sw/, /tw/, /gl/, /tr/, and final /pt/, /ps/.

Participant 3

Participant 3 demonstrated generalization of multiple oppositions intervention across phoneme placement (initial, medial, final) within targeted collapses.

Although /d/ was only targeted in the initial position, participant 3 demonstrated a shrinkage of 1:8 to 1:3 in the medial position.

Participant 3 also demonstrated generalization of multiple oppositions intervention across untargeted collapses. Notable disappearance of collapses include initial /r/ collapse at 1:3, initial /tʃ/ collapse at 1:4, initial /b/ collapse at 1:2, and final /f/ collapse at 1:2. Several 1:1 collapses disappeared, including,

medial /ð/, initial /f/, medial /b/, medial /m/, initial /n/, and initial clusters /gr/, /fr/, /sn/, medial cluster /ts/, and final cluster /nt/.

Participant 4.1

Participant 4.1 demonstrated generalization of multiple oppositions intervention across untargeted collapses. Notable shrinking of collapses included initial /j/ from 1:3 to 1:1. Additionally, several 1:1 collapses disappeared, including, initial /v/, initial /s/, initial /g/, initial /l/, medial /b/, medial /n/ and initial clusters /kw/, /kl/, and /pw/.

Participant 4.2

Participant 4.2 demonstrated generalization of multiple oppositions intervention across untargeted phonemes and phoneme placement (initial, medial, final) within targeted collapses. Only participant 4.2's initial /d/ collapse was targeted over the course of the semester, but his medial /d/ collapse also shrunk from 1:4 to 1:1 and his final /d/ collapse completely disappeared from 1:1 to 1:0. Additionally, only his final omission collapse was targeted over the course of the semester, but his initial and medial omission collapses both shrunk from 1:2 to 1:1.

Participant 4.2 also demonstrated generalization of multiple oppositions intervention across untargeted collapses. Notable shrinking of collapses include initial /w/ from 1:4 to 1:1 and disappearance of collapses including, initial /n/, final /n/, initial /r/, all from 1:2 and medial /t/ from 1:3. Additionally, several 1:1 collapses disappeared, including, initial /b/, initial /f/, initial /t/, initial /m/, initial /j/, initial /tʃ/, medial /n/, medial /l/, final /v/, final /m/, initial clusters /tr/, /wr/, /pr/, /dw/, and final cluster /nk/.

Summary

Unlike local generalization mentioned previously, generalization that is considered within-class and across-class has a larger impact on the child's phonetic inventory. Gierut (2001) states that in this broader generalization, "the extension of learning is to untreated but related members of a sound category" (pg. 230). Treatment of the targeted collapses throughout the semester generalized to untreated collapses in terms of position and sound class.

While several of the participant's experienced a shrinkage or disappearance of collapses, it should be noted that some of the participants experienced a growth in collapse size. This represents the growth of their overall phonetic inventories, and should be considered a positive outcome. For example, following intervention, Participant 1's initial /j/ collapse grew from 1:0 to 1:2, as

Participant 1 produced /j/ for /z, vj/. While this may initially appear to be failed progress, upon further investigation of the child's phonetic inventory, it actually demonstrates growth. Prior to intervention, Participant 1 substituted initial omission for /vj/. Following intervention, Participant 1 produced /j/ for /vj/. The production of /j/ is a much closer approximation to /vj/ than an omission. The phoneme produced became a closer approximate to the target phoneme. Likewise, prior to treatment Participant 1 produced initial /w/ for the consonant clusters /sw, dr, br, kl, fl, gl, θr/. Following a semester of multiple oppositions treatment, Participant 1 produced correct consonant + /w/ for the consonant clusters: /br, gr, dr, pr, gl, pl, bl/. Participant 1's initial /w/ collapse shrunk from 1:9 to 1:4 and his correct consonant + /w/ collapse grew from 1:0 to 1:7. Correct consonant + /w/ is a much closer approximate to the target consonant clusters than /w/ alone.

Additionally, some of the collapses remained the same size, however resulted in different phoneme collapses. For example, Participant 4.1's final /f/ collapse was 1:1 both prior to and following intervention. However, prior to intervention Participant 4.1 substituted /f/ for /θ/. Following intervention Participant 4.1 substituted /f/ for /ft/, which is a closer approximation to /f/ than /θ/. Although the collapse size did not change, the phoneme produced became a closer approximate to the target phoneme. Again, this should be considered a positive outcome in that it represents the maturing of the phonetic inventory.

Participant Comparison

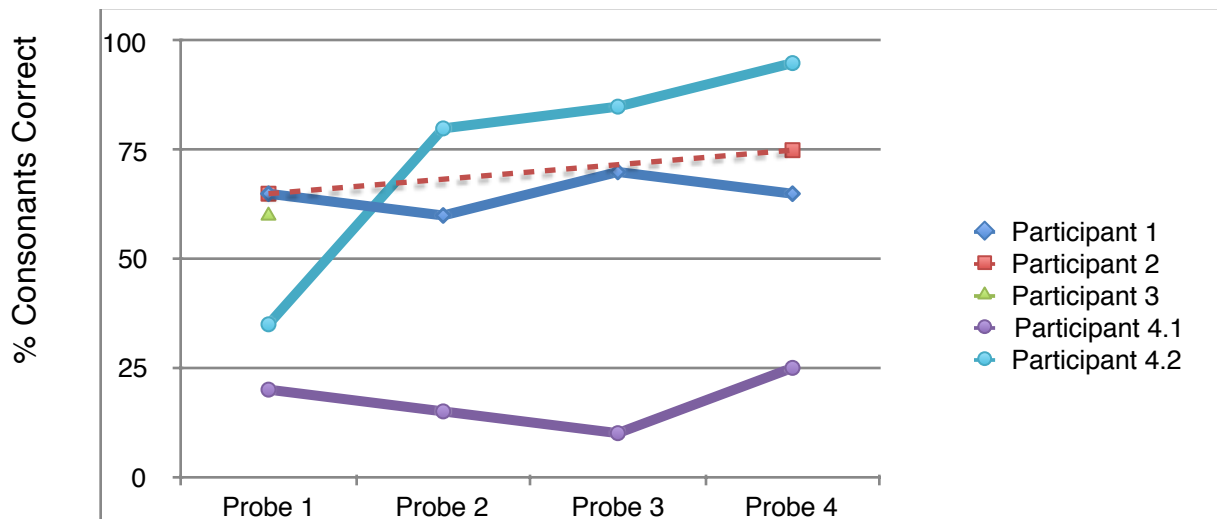
Table 7 displays summary of results for all participants following one treatment semester of multiple oppositions intervention. Percent Change Pre-Post Multiple Oppositions Intervention refers to change in accuracy of target sounds from Probe 1 at beginning of semester to Probe 4 at end of semester.

Table 7 and Figure 3 display each participant's progress according to probe administration of *trained* words throughout the semester:

Table 7. Results all participants trained probe words

Participant	% Target Sound Correct: Probe 1	% Target Sound Correct: Probe 2	% Target Sound Correct: Probe 3	% Target Sound Correct: Probe 4	% Change Pre-Post Multiple Oppositions Intervention
Participant 1	65	60	70	65	0
Participant 2	65	-	-	75	10
Participant 3	60	-	-	-	-
Participant 4.1	20	15	10	25	5
Participant 4.2	35	80	85	95	60

Figure 3. Results all participants trained probe words



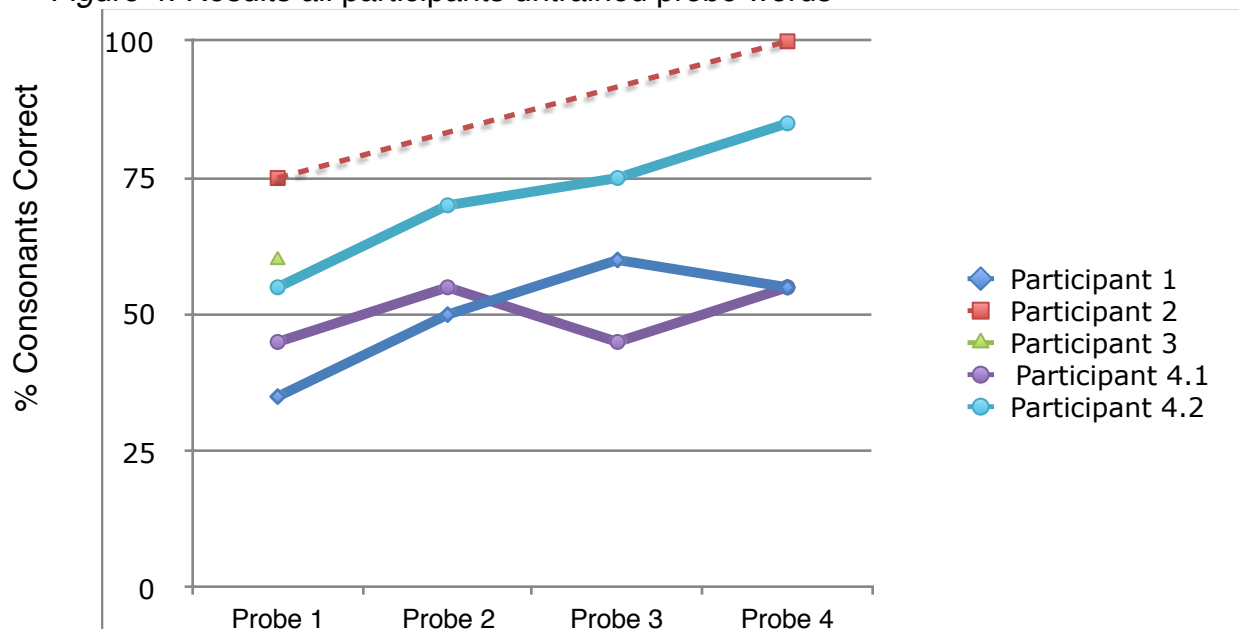
Note: Dashed line denotes incomplete data set

Table 8 and Figure 4 display each participant's progress according to probe administration of *untrained* words throughout the semester:

Table 8. Results all participants untrained probe words

Participant	% Target Sound Correct: Probe 1	% Target Sound Correct: Probe 2	% Target Sound Correct: Probe 3	% Target Sound Correct: Probe 4	% Change Pre-Post Multiple Oppositions Intervention
Participant 1	35	50	60	55	20
Participant 2	75	-	-	100	25
Participant 3	60	-	-	-	-
Participant 4.1	45	55	45	55	10
Participant 4.2	55	70	75	85	30

Figure 4. Results all participants untrained probe words



Note: Dashed line denotes incomplete data set

Summary

All but one participant demonstrated improvement on trained and untrained probes from pre-treatment to post-treatment. Improvements on trained words demonstrate the success of multiple oppositions intervention in training target sounds in words. Improvements on untrained words demonstrate the success of multiple oppositions in generalizing to words not directly targeted in therapy.

Compared To Previous Findings

Findings from this study are consistent with previous studies that report the shrinkage and elimination of collapses following multiple oppositions intervention (Cathell and Ruscello, 2004; Kalbfleisch, 2001; Liles & Williams, 2006; Marcum & Williams,

2005; Paglairin, 2009; as cited by Williams, 2010). The study by Williams and Kalbfleisch (2001) describes systemwide phonological change as a result of multiple oppositions intervention (as cited by Williams, 2010, p.80). Studies by Cathell and Ruscello (2004) and Paglairin (2009) describe the acquisition of phonemes and expansion of the participants' phonemic inventories following multiple oppositions intervention (as cited by Williams, 2010).

Compared To Other Intervention Options

So, is multiple oppositions the best available treatment for children who are highly unintelligible? That cannot be determined from this study, as it has not compared multiple oppositions to any other treatment options. This study has validated, however, that multiple oppositions is *one* effective treatment in terms of the ability to change a child's phonetic inventory following one semester of treatment. Williams (2000b) does predict that multiple oppositions may have more potential to restructure phonology than singular contrast approaches because a multiple oppositions approach considers the entirety of a child's error pattern rather than an isolated aspect of his or her phonological system. Consideration of the entirety of the child's error pattern has been demonstrated by the shrinkage of the participant's untrained collapses.

Strengths and Limitations

The retrospective nature of this study limited control over its design. Due to lack of follow-up, some of the data gathered for this study is incomplete, particularly probe

results for participants 2 and 3. Regarding probes, each participant's list remained the same throughout the semester of intervention, which may have contributed to a learned effect. Despite lack of study control, this study should be considered reliable. All participants were treated at MSHC, had the same clinical supervisor, were administered the same probe testing to gather phonetic inventories, were administered similar probes throughout the semester, and implementation of multiple oppositions intervention was generally consistent across participants.

Implications For Future Studies:

This study serves as a preliminary study and is valuable as it continues Williams' research outside of her lab. Well-designed randomized control studies are needed to validate that multiple oppositions is an effective and efficient form of treatment for children who are highly unintelligible. In addition, studies that compare treatments, such as multiple oppositions and minimal pairs, would be valuable in determining the best course of action for these children.

Conclusions:

A retrospective methodology was used to gather clinical information on four participants over the course of one semester of multiple oppositions intervention. Following one semester of multiple oppositions intervention, trained and untrained collapses in the participants' phonetic inventories shrunk. Participants also demonstrated positional and sound generalization to untrained sounds. In addition, improvements on trained and untrained probes from pre-treatment to post-treatment further validate

a multiple oppositions approach to intervention for highly unintelligible children.

These findings were consistent with previous literature. Additional, studies are needed to further validate a minimal oppositions approach to intervention for highly unintelligible children.

APPENDIX A

Table A1. Description of participants.

Partici- pant	Gender	Age at beginning of study	Race/ Ethnicity	Previous Therapy	Hours Treatment	Number of Trained Collapses
1	Male	3; 8	Hispanic	ECI, 2 semesters MSHC	13	4
2	Female	3; 10	White	1 semester MSHC	11	2
3	Female	6; 5	White	6 semesters MSHC	10.5	3
4.1	Male	6; 0	White	4 semesters MSHC	10	3
4.2	Male	6; 9	White	5 semesters MSHC	10	2

APPENDIX B

Below is an example of a session targeting the collapse of final omission of consonants:

Semester goal- *XX will produce word set for final /-/ for /d, tʃ, s, dʒ, st, sk, ts, ft/ in modeled words with 60% accuracy.*

- | | |
|---------------|---|
| 1:00pm-1:03pm | Word set 1 (“fee,” “feed,” “feast,” and “feats”) reviewed with client |
| 1:03pm-1:15pm | Word set 1 targeted through story presentation |
| 1:15-1:18 | Word set 2 (“la,” “loss,” “lost,” “loft,” and “lodge”) reviewed with client |
| 1:18-1:30 | Word set 2 targeted through drill-based bingo game |

APPENDIX C

Probe Results

Table C1. Probe Results Participant 1

<u>TRAINED</u>	Target	Probe 1	Probe 2	Probe 3	Probe 4
Bit	/b/	+	+	+	+
Cola	/l/	-	-	-	-
Badger	/dʒ/	-	-	-	-
Dime	/d/	+	+	+	+
Hotel	/t/	-	+	+	+
Ball	/b/	+	+	+	+
Wit	/w/	+	+	+	+
Dan	/d/	+	+	+	+
Belly	/l/	+	-	+	-
Tan	/t/	+	+	+	+
Bill	/b/	+	+	+	+
Dart	/d/	+	+	+	+
Sill	/s/	-	-	-	-
Motel	/t/	+	-	+	+
Duck	/d/	+	+	+	+
Pan	/p/	+	+	+	+
Magic	/dʒ/	-	-	-	-
Sit	/s/	-	-	-	-
Bowling	/l/	-	-	-	-
Deck	/d/	+	+	+	+
% Correct		65%	60%	70%	65%
<u>UNTRAINED</u>	Target	Probe 1	Probe 2	Probe 3	Probe 4
Skull	/sk/	-	-	-	-

Troll	/tr/	-	+	-	+
Joy	/dʒ/	-	-	+	+
Kid	/k/	-	+	+	+
Bin	/b/	+	+	+	+
Rid	/r/	-	+	+	-
Slide	/sl/	-	-	-	-
Diet	/d/	+	+	+	+
Tiny	/t/	+	+	+	+
Sud	/s/	-	-	-	-
Thank	/θ/	-	+	+	-
Dry	/dr/	-	+	+	+
Hotel	/t/	-	+	+	+
Budget	/dʒ/	-	-	-	-
Hog	/g/	+	-	+	+
Wok	/k/	+	+	+	+
Hide	/d/	+	-	+	+
Wisk	/sk/	-	-	-	-
Fits	/ts/	+	-	-	-
Mist	/st/	-	-	-	-
% Correct		35%	50%	60%	55%

Table C2. Probe Results Participant 2

TRAINED	Target	Probe 1	Probe 2	Probe 3	Probe 4
Slip	/sl/	+			+
Skip	/sk/	+			+
Rust	/st/	-			+

Slot	/sl/	+			+
Mast	/st/	-			-
Spore	/sp/	+			+
Scoop	/sk/	+			+
Spoke	/sp/	+			+
Cats	/ts/	-			+
Mask	/sk/	-			-
Store	/st/	+			+
Ruts	/ts/	+			+
Snoop	/sn/	+			+
Cast	/st/	+			-
Risk	/sk/	-			-
Snip	/sn/	+			+
Smoke	/sm/	+			+
Mats	/ts/	+			+
Wrist	/st/	-			+
Rusk	/sk/	-			-
% Correct			65%		75%
<u>UN- TRAINED</u>	Target	Probe 1	Probe 2	Probe 3	Probe 4
Skull	/sk/	+			+
Troll	/tr/	+			+
Joy	/dʒ/	-			+
Kid	/k/	+			+
Bin	/b/	+			+
Rid	/r/	-			+
Slide	/sl/	-			+

Diet	/d/	+			+
Tiny	/t/	+			+
Sud	/s/	+			+
Thank	/θ/	+			+
Dry	/dr/	-			+
Hotel	/t/	+			+
Budget	/dʒ/	+			+
Hog	/g/	+			+
Wok	/k/	+			+
Hide	/d/	+			+
Wisk	/sk/	+			+
Fits	/ts/	+			+
Mist	/st/	-			+
% Correct			75%		100%

Table C3. Probe Results Participant 3

TRAINED	Target	Probe 1
Tige	/g/	-
Slink	/sl/	-
Leek	/k/	+
Kill	/k/	+
Tide	/d/	+
Drink	/dr/	+
Sky	/sk/	-
Make	/k/	+
Seer	/r/	+

Fill	/f/	+
Bill	/b/	+
League	/g/	-
Think	/θ/	+
Maid	/d/	+
Clink	/kl/	-
Leer	/r/	-
Seed	/d/	+
Tire	/r/	+
Skill	/sk/	-
Seek	/k/	-
% Correct		60%
<u>UNTRAINED</u>	Target	Probe 2
Skull	/sk/	-
Troll	/tr/	+
Joy	/dʒ/	+
Kid	/k/	-
Bin	/b/	+
Rid	/r/	+
Slide	/sl/	+
Diet	/d/	+
Tiny	/t/	+
Sud	/s/	-
Thank	/θ/	+
Dry	/dr/	+
Hotel	/t/	-
Budget	/dʒ/	+

Hog	/g/	-
Wok	/k/	-
Hide	/d/	+
Wisk	/sk/	-
Fits	/ts/	+
Mist	/st/	-
% Correct		60%

Table C4. Probe Results Participant 4.1

TRAINED	Target	Probe 1	Probe 2	Probe 3	Probe 4
See	/s/	-	-	-	-
Dusk	/sk/	-	-	-	-
Loss	/s/	+	-	-	-
Spill	/sp/	-	-	-	-
Thor	/θ/	-	-	-	+
Zoo	/z/	-	-	-	-
Dutch	/tʃ/	-	-	+	+
Skill	/sk/	-	-	-	-
Fuse	/fj/	+	+	-	-
Jot	/dʒ/	-	-	-	-
Cod	/d/	+	+	+	+
Drill	/dr/	-	-	-	-
Muse	/mj/	+	+	-	-
Try	/tr/	-	-	-	-
Dust	/st/	-	-	-	-
Jill	/dʒ/	-	-	-	-

Lodge	/dʒ/	-	-	-	+
Chill	/tʃ/	-	-	-	+
Cots	/ts/	-	-	-	-
Coughed	/ft/	-	-	-	-
% Correct		20%	15%	10%	25%
UNTRAINED	Target	Probe 1	Probe 2	Probe 3	Probe 4
Skull	/sk/	-	-	-	-
Troll	/tr/	-	-	-	-
Joy	/dʒ/	-	-	-	+
Kid	/k/	+	+	+	+
Bin	/b/	+	+	+	+
Rid	/r/	+	+	-	+
Slide	/sl/	+	+	-	+
Diet	/d/	+	+	+	+
Tiny	/t/	+	+	+	+
Sud	/s/	-	-	-	-
Thank	/θ/	-	-	+	-
Dry	/dr/	-	-	-	-
Hotel	/t/	+	+	+	+
Budget	/dʒ/	-	+	-	-
Hog	/g/	+	+	+	+
Wok	/k/	+	+	+	+
Hide	/d/	-	+	+	+
Wisk	/sk/	-	-	-	-
Fits	/ts/	-	-	-	-
Mist	/st/	-	-	-	-
% Correct		45%	55%	45%	55%

Table C5. Probe Results Participant 4.2

TRAINED	Target	Probe 1	Probe 2	Probe 3	Probe 4
Bass	/s/	-	+	+	+
Ape	/p/	+	+	+	+
Ties	/z/	-	-	-	+
Zip	/z/	-	+	+	+
Try	/tr/	+	+	+	+
Seat	/t/	-	+	+	+
Ace	/s/	-	+	+	+
Jip	/dʒ/	+	+	+	+
Scrip	/skr/	-	-	-	-
Scam	/sk/	-	+	-	+
Seep	/p/	-	+	+	+
Ate	/t/	+	+	+	+
Sigh	/s/	-	+	+	+
Bad	/d/	+	+	+	+
Sky	/sk/	-	-	+	+
Type	/p/	+	+	+	+
Thigh	/θ/	+	+	+	+
Seed	/d/	-	+	+	+
Sty	/st/	-	-	+	+
Sam	/s/	-	+	+	+
% Correct		35%	80%	85%	95%
UNTRAINED	Target	Probe 1	Probe 2	Probe 3	Probe 4
Skull	/sk/	-	-	+	+
Troll	/tr/	-	+	+	+

Joy	/dʒ/	-	+	+	+
Kid	/k/	+	+	+	+
Bin	/b/	+	+	+	+
Rid	/r/	-	-	-	-
Slide	/sl/	+	+	+	+
Diet	/d/	+	+	+	+
Tiny	/t/	+	+	+	+
Sud	/s/	-	-	+	+
Thank	/θ/	-	+	+	+
Dry	/dr/	+	+	+	+
Hotel	/t/	+	+	+	+
Budget	/dʒ/	+	+	+	+
Hog	/g/	+	+	-	+
Wok	/k/	+	+	+	+
Hide	/d/	+	+	+	+
Wisk	/sk/	-	-	-	-
Fits	/ts/	-	-	-	+
Mist	/st/	-	-	-	-
% Correct		55%	70%	75%	85%

APPENDIX D

Collapse Results

Table D1. Complete Collapse Results Participant 1

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
Omission	/sl, k, f, z, kr, w, s, vj, g, b, p, θ/		/j, l, θ, k, r, dʒ, t, g, s, ʃ/	/k, t, g, ŋ, s, ʃ, f, z/	/r, t, k/	/θ/	I: 1:12 to 1:0 M: 1:10 to 1:8 F: 1:3 to 1:0	I: 100% M: 20% F: 100%
/b/	/v, bl, tw, pr, sk/	/v/	/v/	/v/			I: 1:5 to 1:1 M: 1:1 to 1:1	I: 80% M: 0%
/p/	/k, sp, fr, pl/	/pj/			/ft/	/pt/	I: 1:4 to 1:1 F: 1:1 to 1:1	I: 75% F: 0%
/d/	/k, θ, dʒ, tʃ, st/	/θ, dʒ/	/t, g, z/	/dʒ/	/dr/	/t/	I: 1:5 to 1:2 M: 1:3 to 1:1 F: 1:1 to 1:0	I: 60% M: 67% F: 100%
/n/	/b, m, sn/	/sn/					I: 1:3 to 1:1	I: 67%
/m/	/mj/		/f/			/mz/	I: 1:1 to 1:0 M: 1:1 to 1:0 F: 1:0 to 1:1	I: 100% M: 100% F: 0%*
/r/					/ʊ, ʌ/		F: 1:2 to 1:0	F: 100%
/w/	/l, r, sw, dr, br, kl, fl, gl, θr/	/l, r, kr, fr/	/r, l/	/r, j/			I: 1:9 to 1:4 M: 1:2 to 1:2	I: 56% M: 0%
/j/		/z, vj/	/tʃ/				I: 1:0 to 1:2 M: 1:1 to 1:0	I: 0%* M: 100%

/t/	/k, s/	/tʃ/	/k/	/tʃ/	/d, p/	/z, ʃ, dʒ/	I: 1:2 to 1:1 M: 1:1 to 1:1 F: 1:2 to 1:3	I: 50% M: 0% I: 0%*
/θ/			/j/				M: 1:1 to 1:0	M: 100%
/h/	/tr/	/s, ʃ, θ, sl/		/ʒ/			I: 1:1 to 1:4 M: 1:0 to 1:1	I: 0%* M: 0%*
/s/		/ʃ/					I: 1:0 to 1:1	I: 0%*
/ʃ/					/s/		F: 1:1 to 1:0	F: 100%
/f/		/fl, fj/					I: 1:0 to 1:2	I: 0%*
/v/		/w/					I: 1:0 to 1:1	I: 0%*
/k/	/d, t, p/	/sk/			/sk/	/sk/	I: 1:3 to 1:1 F: 1:1 to 1:1	I: 67% F: 0%
/g/						/gz/	F: 1:0 to 1:1	F: 0%*
Correct consonant + /w/		/br, gr, dr, pr, gl, pl, bl/					I: 1:0 to 1:7	I: 0%*
/bw/	/gr/						I: 1:1 to 1:0	I: 100%
/dw/		/θr/					I: 1:0 to 1:1	I: 0%*
/pl/		/kl/					I: 1:0 to 1:1	I: 0%*
/ts/		/s, st, tʃ/					I: 1:0 to 1:3	I: 0%*

* Indicates growth in collapse

Table D2. Complete Collapse Results Participant 2

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
Omission	/p/		/r, v, d/		/p, f, d/	/d/	I: 1:1 to 1:0 M: 1:3 to 1:0 F: 1:3 to 1:1	I: 100% M: 100% F: 67%
/t/	/sw/				/w, θ/	/ts/	I: 1:1 to 1:0 F: 1:2 to 1:1	I: 100% F: 50%
/ə/			/r/	/r/	/r/	/r/	M: 1:1 to 1:1 F: 1:1 to 1:1	M: 0% F: 0%
/l/	/gl/	/sl/			/d/		I: 1:1 to 1:1 F: 1:1 to 1:0	I: 0% F: 100%
/w/	/l, r, gr, br, tw/	/gr/		/l/			I: 1:5 to 1:1 M: 1:0 to 1:1	I: 80% M: 0%*
/b/	/v/				/v/		I: 1:1 to 1:0 F: 1:1 to 1:0	I: 100% F: 100%
/p/			/f, s/				M: 1:2 to 1:0	M: 100%
/m/		/w/					I: 1:0 to 1:1	I: 0%*
/k/	/pr, kl/						I: 1:2 to 1:0	I: 100%
/f/	/v, ð/	/ð/					I: 1:2 to 1:1	I: 50%
/tʃ/	/ʃ, ʃr/		/dʒ/		/ʃ/		I: 1:2 to 1:0 M: 1:1 to 1:0 F: 1:1 to 1:0	I: 100% M: 100% F: 100%
/dʒ/	/ʃ, dr, sl/		/ʒ/				I: 1:3 to 1:0 M: 1:1 to 1:0	I: 100% M: 100%

/ʒ/	/ʃ/						I: 1:1 to 1:0	I: 100%
/ʃ/		/tʃ, ʃr/					I: 1:0 to 1:2	I: 0%*
Omission / s/ + Conso- nant	/sk, sw, sl, sn, sp, sm, skr, spl/	/sn/			/st, sk/	/st/	I: 1:8 to 1:1 F: 1:2 to 1:1	I: 88% F: 50%
/s/	/ð/				/z, st, sk, ts/		I: 1:1 to 1:0 F: 1:4 to 1:0	I: 100% F: 100%
/z/					/st, ts/		F: 1:2 to 1:0	F: 100%
/st/	/s/						I: 1:1 to 1:0	I: 100%
/sk/		/skr/					I: 1:0 to 1:1	I: 0%*
/sw/	/str/						I: 1:1 to 1:0	I: 100%
/tw/	/sw/						I: 1:1 to 1:0	I: 100%
/pw/		/pr/					I: 1:0 to 1:1	I: 0%*
/pt/					/pw/		F: 1:1 to 1:0	F: 100%
/ps/					/pt/		F: 1:1 to 1:0	F: 100%
/kl/	/gl/						I: 1:1 to 1:0	I: 100%
/tə/	/tr/						I: 1:1 to 1:0	I: 100%
/ɛ/			/ɾ/				M: 1:1 to 1:0	M: 100%

* Indicates growth in collapse

Table D3. Complete Collapse Results Participant 3

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
Omission	/p, k/	/sn, sm/	/g/	/g, l/	/k, r, g, d, s/	/k, r, g, d, s/	l: 1:2 to 1:2 M: 1:1 to 1:2 F: 1:5 to 1:5	l: 0% M: 0%* F: 0%
/d/	/sk, k, b, g, tr, t, f, v, s, ʃ, ʃr, dʒ/	/p, b, v, g, st, tʃ/	/t, v, f, g, k, ð, θ, h/	/t, g, θ/		/b, g/	l: 1:12 to 1:6 M: 1:8 to 1:3 F: 1:0 to 1:2	l: 50% M: 63% F: 0%*
/w/	/ð, θ, l, r, gl, dr, sl, sw, kl/	/l, r/	/l/	/l/			l: 1:9 to 1:2 M: 1:1 to 1:1	l: 78% M: 0%
/t/	/tʃ, sk/	/k, v/				/k/	l: 1:2 to 1:2 F: 1:0 to 1:1	l: 0% F: 0%*
/s/		/sk/			/st, sk/		l: 1:0 to 1:1 F: 1:2 to 1:0	l: 0%* F: 100%
/tʃ/	/s, fʃ, pj, kj/			/k/			l: 1:4 to 1:0 M: 1:0 to 1:1	l: 100% M: 0%*
/ð/			/ʒ/				M: 1:1 to 1:0	M: 100%

/f/	/fl/				/θ, ft/		I: 1:1 to 1:0 F: 1:2 to 1:0	I: 100% F: 100%
/b/	/p, bl/		/fl/				I: 1:2 to 1:0 M: 1:1 to 1:0	I: 100% M: 100%
/m/	/mj, j/	/mj/	/n/			/n/	I: 1:2 to 1:1 M: 1:1 to 1:0 F: 1:0 to 1:1	I: 50% M: 100% F: 0%*
/n/	/m/				/ŋ/		I: 1:1 to 1:0 F: 1:1 to 1:0	I: 100% F: 100%
/nt/					/nk/		F: 1:1 to 1:0	F: 100%
/r/	/w, θr, pl/						I: 1:3 to 1:0	I: 100%
/sw/	/mj, j/	/spl, sk, sl/					I: 1:2 to 1:3	I: 0%*
/sn/	/sm/						I: 1:1 to 1:0	I: 100%
/ts/			/dʒ/				M: 1:1 to 1:0	M: 100%
/dr/	/br, kr/	/gr, pr/					I: 1:2 to 1:2	I: 0%
/gr/	/tr/						I: 1:1 to 1:0	I: 100%
/fr/	/pr/						I: 1:1 to 1:0	I: 100%
Correct consonant + /w/	/dr, kr, bl/	/kl, gl/					I: 1:3 to 1:2	I: 33%

* Indicates growth in collapse

Table D4. Complete Collapse Results Participant 4.1

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
/d/	/s, z, θ, dʒ, sk, dr, tr/	/s, f, θ, ð, dʒ, sk, str/	/z, tʃ, θ, ð, ʒ, dʒ/	/z, ʒ, ð, tʃ, dʒ/	/z/	/z, g/	I: 1:7 to 1:7 M: 1:6 to 1:5 F: 1:1 to 1:2	I: 0% M: 17% F: 0%*
/dr/		/sk/					I: 1:0 to 1:1	I: 0%*
Omission	/tʃ, dʒ, sp, mj, fj/	/dʒ, j, sp/	/b, s/	/b, s, f, θ/	/d, tʃ, s, dʒ, st, sk, ts, ft/	/s, θ, ft/	I: 1:5 to 1:3 M: 1:2 to 1:4 F: 1:8 to 1:3	I: 40% M: 0%* F: 63%
/b/	/br/	/br/	/v/			/p/	I: 1:1 to 1:1 M: 1:1 to 1:0 F: 1:0 to 1:1	I: 0% M: 100% F: 0%*
/bl/		/pl/					I: 1:0 to 1:1	I: 0%*
/n/	/sn/	/sn/	/ŋ/			/nd/	I: 1:1 to 1:1 M: 1:1 to 1:0 F: 1:0 to 1:1	I: 0% M: 100% F: 0%*
/f/	/fl/	/v/			/θ/	/ft/	I: 1:1 to 1:1 F: 1:1 to 1:1	I: 0% F: 0%
/v/	/ð/						I: 1:1 to 1:0	I: 100%

/f/	/tʃ, fr, sr/	/fr/						I: 1:3 to 1:1	I: 67%
/tʃ/		/tr/				/f/		I: 1:0 to 1:1 F: 1:0 to 1:1	I: 0%* F: 0%*
/w/	/r, sw/	/j, sw, kw/						I: 1:2 to 1:3	I: 0%*
/s/	/sl/							I: 1:1 to 1:0	I: 100%
/m/	/sm/	/sm, mj/			/mz/	/mz/		I: 1:1 to 1:2 F: 1:1 to 1:1	I: 0%* F: 0%
/g/	/skr/				/gz/	/gz/		I: 1:1 to 1:0 F: 1:1 to 1:1	I: 100% F: 0%
/p/					/ps/	/ps/		F: 1:1 to 1:1	F: 0%
/pw/	/pr/							I: 1:1 to 1:0	I: 100%
/k/	/kr/	/dr/			/sk/	/sk/		I: 1:1 to 1:1 F: 1:1 to 1:1	I: 0% F: 0%
/kl/	/sl/							I: 1:1 to 1:0	I: 100%
/kw/	/tw/							I: 1:1 to 1:0	I: 100%

/l/	/θr/						l: 1:1 to 1:0	l: 100%
/t/	/ft/	/g, sl, tw/			/ft/	/st, ts/	l: 1:1 to 1:3 F: 1:1 to 1:2	l: 0%* F: 0%*
/fj/	/vj/	/j/					l: 1:1 to 1:1	l: 0%

* Indicates growth in collapse

Table D5. Complete Collapse Results Participant 4.2

Production	Initial		Medial		Final		Shrinkage	% Shrinkage
	Pre	Post	Pre	Post	Pre	Post		
/d/	/s, z, dʒ, sk, θ, tr, sk, skr, st/	/s, sk, st, skr/	/dʒ, ʃ, s, z/	/z/	/s/		l: 1:9 to 1:4 M: 1:4 to 1:1 F: 1:1 to 1:0	l: 56% M: 75% F: 100%
Omission	/m, s/	/s/	/dʒ, g/	/s/	/d, s, z, p, t/	/s, z/	l: 1:2 to 1:1 M: 1:2 to 1:1 F: 1:5 to 1:2	l: 50% M: 50% F: 60%
/b/	/v/						l: 1:1 to 1:0	l: 100%
/n/	/s, sn/		/z/		/s, z/		l: 1:2 to 1:0 M: 1:1 to 1:0 F: 1:2 to 1:0	l: 100% M: 100% F: 100%
/v/					/ð/		F: 1:1 to 1:0	F: 100%

/f/	/fr/						I: 1:1 to 1:0	I: 100%
/w/	/r, sw, fr, b/	/r/			/θ/	/ft/	I: 1:4 to 1:1 F: 1:1 to 1:1	I: 75% F: 0%
/s/		/f/					I: 1:0 to 1:1	I: 0%*
/t/	/sl/		/dʒ, s, θ/		/st, ts/	/st, ts/	I: 1:1 to 1:0 M: 1:3 to 1:0 F: 1:2 to 1:2	I: 100% M: 100% F: 0%
/m/	/sm/				/ms/		I: 1:1 to 1:0 F: 1:1 to 1:0	I: 100% F: 100%
/b/	/v, sp/						I: 1:2 to 1:0	I: 100%
/r/	/w, z/						I: 1:2 to 1:0	I: 100%
/l/		/s/	/r/				I: 1:0 to 1:1 M: 1:1 to 1:0	I: 0%* M: 100%
/tʃ/	/θ/			/dʒ/			I: 1:1 to 1:0 M: 1:0 to 1:1	I: 100% M: 0%*
/dʒ/		/tʃ/	/ʒ/				I: 1:0 to 1:1 M: 1:0 to 1:1	I: 0%* M: 0%*
/k/		/kr/		/f/	/sk/	/sk/	I: 1:0 to 1:1 M: 1:0 to 1:1 F: 1:1 to 1:1	I: 0%* M: 0%* F: 0%

/j/	/dj/						l: 1:1 to 1:0	l: 100%
/tr	/tw/						l: 1:1 to 1:0	l: 100%
/wr/	/br/						l: 1:1 to 1:0	l: 100%
/pr/	/tr/						l: 1:1 to 1:0	l: 100%
/dw/	/str/						l: 1:1 to 1:0	l: 100%
/gw/		/gr/					l: 1:0 to 1:1	l: 0%*
/nk/					/sk/		F: 1:1 to 1:0	F: 100%
/sn/		/s/					l: 1:0 to 1:1	l: 0%*
/sl/		/s/					l: 1:0 to 1:1	l: 0%*

* Indicates growth in collapse

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