Kindergarten Readiness Summer Speech Boot Camp—Can Children Make Enough Gains in Their Stimulability of Target Sounds Over Summer Break?

By

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Abstract

Children with mild-to-moderate speech sound disorder (SSD) often don't qualify for an Individualized Education Plan (IEP) in the public-school setting as a result of the large caseloads that school-based speech-language pathologists (SLP) have. Previous studies have shown promise in intensive speech programs that target specific sounds to help children improve their overall production accuracy. This study examined the potential of a short-term, intensive program that occurred during the summer before a child began school. Four children with mild-to-moderate SSD who were planning on starting Kindergarten the following fall semester participated in the summer speech boot camp study. Results showed that this program design coupled with using the complexity approach may help children with mild-to-moderate articulation deficits rapidly improve their speech prior to starting Kindergarten. Possible modifications to the treatment based on these findings are discussed.

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Introduction

A speech sound disorder (SSD) is a communication disorder that presents as a delayed acquisition of speech sounds for a person's age (Lewis, Shriberg, Freebairn, Hansen, Stein, Taylor, & Iyengar, 2006). SSD has an estimated prevalence of more than 3.8% in children who are 6-years-old, with much higher rates in children who are younger (Lewis et al., 2006). Additionally, speech therapy is the most frequent type of service provided by speech-language pathologists (SLP) in schools (ASHA Schools Survey Report, 2014). However, due to the typically large caseloads that school SLP's have, young children who present with a mild-to-moderate SSD sometimes don't qualify for services immediately. If left untreated, SSD can lead to an increased difficulty with reading and spelling and cause socioemotional difficulties (Lewis et al., 2006; McCormack, McLeod, McAllister, & Harrison, 2009). However, research has shown that the key to best prepare children with SSD for academic success is to provide them with early and effective intervention (Beitchman, Wilson, Johnson, Atkinson, Young, Adlaf, Escobar, & Douglas, 2001; Nathan, Stackhouse, Goulandris, & Snowling, 2004). While there is a large research base of standard intervention practices for treating children with SSD (Baker & McLeod, 2011), there is not research examining short and intensive speech intervention using the complexity approach for pre-Kindergarten-aged children.

The complexity approach is used to target sounds that are harder to acquire because targeting those sounds can have a "trickle down" effect on easier phonemes that the child might also struggle to produce. Using the complexity approach can lead to system-wide changes in speech that can help children acquire a broader learning of speech sounds (Gierut, 1998, 2001). Most studies cite the complexity approach as being used with 3 to 6-year old's who have moderate to severe articulation needs (Storkel, 2018). There are four different factors used to

select sounds when using the complexity approach. The first factor is developmental norms. Developmental norms mark a target age range where children typically begin producing a target sound (Storkel, 2018). The range begins at the age where at least 50% to 75% of children are producing the sound correctly (Sander, 1972; Templin, 1957) and ends when at least 90% of children can produce the sound correctly (Smit, Hand, Freilinger, Bernthal, & Bird, 1990). When referencing early-acquired sounds, the target is a sound that is typically acquired 1 or more years before the child's age (Storkel, 2018). So, for a 4-year-old child, an early-acquired sound would be sounds with a 90% age of acquisition of 3- years or earlier. A late-acquired sound refers to a sound that is acquired 1 or more years beyond the child's age (Storkel, 2018). So, for a 4-year old child, a late-acquired sound would be sounds with a 90% age of acquisition of 5-years or later. Late-acquired sounds are the targets that are usually selected for the complexity approach due to the possibility of leading to a system wide change. Studies show that children receiving treatment for late acquired sounds make greater improvements in accuracy of speech sound production than children who receive treatment for early acquired sounds (Gierut et al., 1996; Gierut and Morrisette, 2012).

The second factor is implicational universals. Implicational universals refer to patterns in a language, specifically phonology, in which there is a co-occurrence of different sound groups in one language (Gierut, 2007; Storkel, 2018). For example, if a language has liquid sounds, it will also have nasal sounds (Storkel, 2018). Additionally, a language will possess only singletons or singletons and clusters (Storkel, 2018). Sound classes that can occur alone and are less complex are referred to as unmarked sounds and sound classes that cannot occur alone and are more complex are referred to as marked sounds (Storkel, 2018). There are also sound productions that are easier to produce than others. Unmarked sounds are usually acquired earlier

than marked sounds because they are easier to produce (Storkel, 2018). Also, nasals and singletons are less complex than liquids and clusters (Storkel, 2018). Thus, the nasals and singletons are typically learned first in a language because they are less complex. The complexity approach prioritizes the more complex sounds (liquids and clusters) over the less complex sounds (nasals and singletons) (Storkel, 2018).

The third factor of the complexity approach is accuracy. Accuracy is the child's ability to produce a target sound correctly. Accuracy is used to determine sound targeting and treatment goals because the sounds with the lowest level of accuracy require the most attention (Storkel, 2018). The complexity approach prioritizes treatment of low accuracy sounds because studies show that treatment of low accuracy sounds lead to greater changes in the child's overall sound system compared to the treatment of higher accuracy sounds, which may even improve without treatment.

The final factor is stimulability. Stimulability assesses the child's ability to produce a target sound after it has been modeled by the clinician (Storkel, 2018). If a child is stimulable for a sound, then they are able to accurately repeat the sound back after a model by the clinician. If a child is not stimulable for a sound, then they are unable to accurately repeat the sound even after a model by the clinician. Within the complexity approach, non-stimulable targets are prioritized (Storkel, 2018).

It has been proposed that by addressing a system-wide change during a time when children are typically expanding their phonemic repertoires (i.e. before they start school) children could learn more sounds and thus, not require services once they begin school (Storkel, 2018). Overall, the complexity approach has shown to be effective in traditional, pull-out individual, intensive treatment formats.

Jennifer Taps-Richard (2012) developed a speech improvement class in the San Diego Unified School District, which was used as the main model for this study. The purpose of this speech improvement class was to provide services for children who had a mild articulation disorder but did not qualify for an IEP (Taps-Richard, 2012). An additional possible benefit was to help lighten the caseload of school-based SLP's kids could potentially move through services more quickly (Taps-Richard, 2012). In order to qualify for this class, children had to exhibit lateralized productions and/or cluster reductions, in addition to being non-stimulable for target sounds. Treatment lasted 20 weeks and occurred during the school day. After the child became stimulable for the sound, Taps-Richard (2012) introduced practice to generalize the sound by doing a randomization of practice words, phrases, and sentences with the target sounds. Motor learning principles, like description of tongue placement for correct production, were implemented in combination with the complexity approach to help target and teach sounds. The results were promising and showed one child who increased from 6 to 19 clusters after 10 hours of treatment (Taps-Richard, 2012). In addition to the participating in the class, participants were also given homework. Although the study reported on requiring homework completion by the participants, it was unclear how homework participation may have influenced outcomes. Additionally, it was unclear if this program could be completed with the same results in a shorter time frame and with younger children.

The goal of this project was to determine whether the complexity approach could be used effectively in a short duration boot camp model with pre-K children with mild-to-moderate SSD. The rationale was that a short-term program, when combined with a homework component, may be sufficient to normalize the speech of children with mild-to-moderate SSD. Improving speech

prior to Kindergarten might also help prevent difficulties learning to read and early academic failure. The study was designed to address the following 2 questions.

Research Questions

1. Is 6 weeks a sufficient amount of time to establish an improved production of a sound that can trigger further change in the sound system?
2. Is homework influential on speech sound improvement?

Methods

Participants

Four children with SSD who planned to start Kindergarten in August of that year (aged 4;6-5;6) were recruited through speech screenings at a local elementary school. The Diagnostic Evaluation of Articulation and Phonology (DEAP) screener was used for recruitment purposes (Dodd, Hua, Crosbie, Holm, & Ozanne, 2006). If a child had 1-2 errors that were not developmentally appropriate, they were marked as 'borderline' and if they had 3 or more errors they were marked as 'did not pass'. Children who were marked as 'borderline' or 'did not pass' received packets of information inviting them to participate in the study. Children who were flagged as borderline were a higher priority because they fit the demographic that the study was targeting (i.e., mild SSD). Children who were flagged by the DEAP screener (Dodd et al., 2006) also had passed the Clinical Evaluation of Language Fundamentals—5th Edition (CELF-5) screener (Wiig, Secord, & Semel, 2013). This was important because it indicated that the child was not recommended for further testing due to weak language skills, which is often associated with poorer academic outcomes. It was hypothesized that children with a mild-to-moderate speech sound disorder without a concomitant language disorder would be more likely to benefit from a short-term summer program.

Of the participants, 50% were male and 50% were female. Table 1 contains a summary of children's demographic information and results on all standardized pre-treatment test measures. Percentile scores are provided for easier comparison of subtest scaled scores and composite scores, which use different scales. Eligible children were required to (1) be enrolled to start Kindergarten in August; (2) pass a hearing screening at 20db for 1000 Hz, 2000 Hz, and 4000 Hz (ASHA, 1997); (3) score between the 6th and 16th percentile on the Arizona Articulation and Phonology Scale-Fourth edition (Fudala & Stegall, 2017); and (4) score at least a standard score of 78 on the Primary Test of Non-Verbal Intelligence (PTONI) (Ehrler & McGhee, 2008). If the child passed the hearing screening and met the criteria for the Arizona-4 and the PTONI, they were then be administered the Core Language Subtests (Sentence Structure, Word Structure, Expressive Vocabulary) of the Clinical Evaluation of Language Fundamentals-Preschool-2nd Edition (CELF P-2) (Semel, Wiig, & Secord, 2004) to evaluate their language skills in addition to the Phonological Awareness subtests (Elision, Blending Words, Sound Matching) of the Comprehensive Test of Phonological Processing-2nd Edition (CTOPP-2) (Wagner, Torgesen, Rashotte, & Pearson, 2013) to evaluate their phonological skills. These additional measures were intended to help describe the characteristics of the children and they were not required to score in a particular range.

Table 1

Percentile scores for participants on standardized clinical tests

	KRSBC 01	**KRSBC 02**	**KRSBC 03**	**KRSBC 04**
Age (as of first day of testing)	5;5	5;1	5;1	5;7
Gender (M/F)	M	F	F	M
Hearing (Pass/Fail)	P	P	P	P
Arizona-4[1]	10	10	6	16
PTONI[2]	63	50	50	55
CELF-P2[3]	70	21	21	25
CTOPP-2[4]	14	18	14	12

[1]Arizona Articulation and Phonology Scale—Fourth Edition (Fudala & Stegall, 2017); [2]Primary Test of Non-Verbal Intelligence (Ehrler & McGhee, 2008); Clinical Evaluation of Language Fundamentals-Preschool-2nd Edition (Semel et al., 2004); [4]Comprehensive Test of Phonological Processing-2nd Edition (Wagner et al., 2013).

As shown in the table, there was some variation in articulation test scores, with one child scoring as low as the 6th percentile (the lowest score before cut-off) and one child scoring as high as the 16th percentile (the highest score before the cut-off). All four children scored near the 50th percentile for non-verbal reasoning. There were, however, a range of language scores. KRSBC 01 scored very high on the CELF P-2 (Semel et al., 2004) while the other 3 participants scored towards the lower end of normal. Finally, phonological awareness was also evaluated. All participants scored relatively within the same range. Their scores indicated that they all had weaker phonological awareness skills.

Speech Sound Evaluation

Once the formal measures were completed, the children were then administered a singleton probe, a cluster probe, and a stimulability probe (Storkel, 2018). The results from these determined the target sounds and established a baseline.

The singleton probe provided a deep articulation test to sample a variety of targets in each word position multiple times (Storkel, 2018). This was important because it allowed the thorough evaluation of a child's speech sound production. The singleton probe targeted mid- and late-acquired singletons with 5 words in the initial position and 5 words in the final position. The targets included /k g f v θ ð s z ʃ ʧ ʤ ŋ l r/. The children were shown pictures depicting the 87 words on the probe and asked to name them. In total, there were 150 different productions evaluated (82 initial, 68 final). The singleton probe was given during the preliminary evaluation to determine which sounds were low accuracy. A sound was considered low accuracy if the child had 0-25% accuracy. The probe was then reduced down to only the low accuracy sounds and that was re-administered throughout the study to track the change.

The cluster probe provided another deep articulation test to sample two- and three-element clusters (Storkel, 2018). The different clusters that were sampled included; l- clusters, r-clusters, s- clusters, and w- clusters. This probe provided two words for each target and the children were shown pictures that depicted the 56 words. The cluster probe was given during the preliminary evaluation to determine which sounds were low accuracy. Again, sounds were considered low accuracy if the child produced them with 0-50% accuracy. The probe was then reduced down to only the low accuracy sounds and that was re-administered throughout the study to track the change.

Stimulability was used as a dynamic assessment of phonology (Storkel, 2018). Stimulability examines the child's ability to correctly produce a sound that they typically produced in error after receiving a model from the clinician (Glaspey et al., 2007). The stimulability probe was used to assess the stimulability of the sounds that the child produced with low accuracy on the singleton and clusters probe. During administration of the singleton probe, the child was asked to imitate the clinician's over-articulated production of a sound in isolation or in syllables (CV, VC, VCV). During administration of the cluster probe, the child was asked to imitate the clinician's over-articulated production of a cluster sound followed by a vowel sound. During the evaluation process, the entire stimulability probe for the low accuracy sounds were administered.

Table 2 and 3 contains a summary of each participants low accuracy sounds on the first administration of the cluster and singleton probes. A sound was marked as stimulable if the child had above a 50% accurate production after a clinician model. Stimulable sounds are marked in bold and underlined.

Table 2

Sounds in error on singleton probe[1]

	Sounds (initial)	Sounds (final)	Total in error (out of 150)
KRSBC 01	**r**, **g**, **l**, **k**, **θ**, **v**	**ʤ**, **ŋ**, **l**, **r**, **θ**, **g**, **ð**, **k**, **f**, **ʧ**	80
KRSBC 02	**θ**, **ʃ**, **ð**, **v**, **r**	**ʃ**, **θ**, **ð**, **z**, **ŋ**	69
KRSBC 03	**k**, **ʧ**, **ʃ**, **r**, **z**, **v**, **θ**, **ʤ**, ð	**ʃ**, **θ**, **ʤ**, ð, **r**	74
KRSBC 04	θ, **ʃ**, **ð**, **l**, **v**, **r**, **g**	**ʃ**, **ʤ**, **f**, **ʧ**, θ, **ð**, **k**, **ŋ**	82

[1](Storkel, 2018).

Table 3

Sounds in error on cluster probe[1]

	Clusters	Total in error (out of 56)
KRSBC 01	**gl**, gr, **st**, **sl**, sk, **sm**, **str**, **spr**, **skw**, **spl**, **skr**, **bl**, **br**, **fr**, **fl**, **pr**, **pl**, **kl**, **kr**, **dr**, **θr**, **tr**, **ʃr**	42
KRSBC 02	**gr**, **sl**, **str**, spr, **skw**, **spl**, skr, **br**, **fr**, **pr**, **kr**, **dr**, **θr**, **tr**, **ʃr**	26
KRSBC 03	**gr**, str, **spr**, skr, **spl**, **br**, **fr**, **pr**, **kr**, **dr**, **θr**, **tr**, ʃr	25
KRSBC 04	**gl**, **gr**, **str**, spr, **skw**, spl, **skr**, **bl**, **br**, **fr**, **fl**, **pr**, **pl**, **kl**, **kr**, θr, **tr**, **ʃr**	32

[1](Storkel, 2018).

Sound Selection

Sounds were selected based on the child's performance on the cluster probe and the cluster stimulability probe. To select the target sound, the child needed to have 0% accuracy for one of the following clusters; /bl/, /gl/, /fl/, /sl/, /θr/, /ʃr/, /br/, /gr/, /fr/, /dr/, because these are the most complex 2-element clusters in the English language. Due to the limited time of the treatment, an "easier" cluster was selected from the ones that were 0% accurate in this group, in

hopes to maximize results. Specific factors to consider a sound “easier” were stimulability (i.e., select a more stimulable cluster) and accuracy of the sounds in the cluster as singletons (i.e., select a cluster with sounds the child could produce as separately as singletons). This is slightly different from the traditional complexity approach, where the sound that is selected typically is not stimulable. However, for the purposes of this study, a stimulable sound was selected due to the short timeframe. The target sound was then selected with the idea that the child had a good foundation for learning it in a short period. Table 4 contains a summary of each participants selected sound along with the stimulability for that sound during pre-testing.

Table 4

Sound selection and stimulability[1]

	Sound	% of stimulability	First sound singleton % accuracy	Second sound singleton % accuracy
KRSBC 01	bl	86%	Not tested	90%
KRSBC 02	ʃr	100%	40%	70%
KRSBC 03	θr	57%	40%	90%
KRSBC 04	fl	43%	100%	60%

[1](Storkel, 2018).

Treatment

The layout of the treatment was based on the Speech Improvement Class created by Jennifer Taps-Richard (2012). For this study, each child had 5 non-words and 5 real words (10 words total), which all included the target sound for treatment. It was hypothesized that non-words could help spark change because the child didn't have to overcome ingrained patterns of producing the word incorrectly. This makes them unique from real words where the child could have a habit of producing the target sound incorrectly. Additionally, studies have shown that the treatment of non-words and real words can lead to greater generalization of both treated and

untreated sounds (Gierut et al., 2010). Table 5 contains a summary of the selected treatment words for this study. All the words used during treatment were different from those included in the singleton probe and the cluster probe. This was important so that the words on the probe would be untreated and thus useful in documenting generalization of the target sound to untreated real words.

Table 5

Treatment words

	Sound	Word list (real words)	Word list (non-words)
KRSBC 01	bl	blue, bleach, blood, blow, blanket	blid, blan, blug, blef, bloop
KRSBC 02	ʃr	shrink, shrub, shred, Shrek, shrill, shriek,	shrid, shroop, shren, shrug, shraf
KRSBC 03	θr	threw, throat, throne, thrift, throw	thrid, throop, thren, throg, thraf
KRSBC 04	fl	flip, flu, float, fly, flash	flid, floop, flen, flug, flaf

The treatment was based on drill-play techniques. Sessions were one-on-one with the child and the researcher in a quiet room at a convenient location in the area (e.g., public library). Occasionally, caregivers sat in on the session to observe, but never participated. Index cards with the target word and a picture that represented that word were used during activities. The same index cards were used every session for consistency. Games were incorporated to keep the child entertained and motivated to work on producing their sounds correctly. Examples of games included; Go Fish using the index cards, a Matching Game using the index cards, and Chutes and Ladders where the child had to produce the target word before each turn. Additionally, a storybook was used every session to introduce the child to the real words and non-words that were used in sessions (Storkel, 2018) (Appendix A). During the beginning of the study, the

storybook was read to the child. As the study progressed and the child became more familiar with the words and the story, the researcher had the child practice story retelling and prompted the child with questions to elicit spontaneous speech using the real words and non-words.

Sessions occurred twice a week for six weeks (12 treatment sessions total). Sessions lasted between 30 and 45 minutes, depending on the child's cooperation and participation level that day. There was a total of 10 stimuli (see Table 5) that were practiced 10 times (100 trials) per session. The data sheet allowed for the researcher to select if the sound was produced at the word level or phrase level and if it was said spontaneously or if it was imitated (Appendix C). After each production, feedback was provided to the child. If the child produced the sound correctly, the researcher would provide positive reinforcement (i.e., "Good job!" or "I like how you said your sound!"). If the child produced the target sound incorrectly, the researcher would repeat back the error and provide feedback to the child (i.e. "Move your tongue to the back" or "Feel the air push out with your hand"). Feedback was only provided on the target sound.

The sessions were set up in the following manner; trial 1 consisted of an imitation production that followed a model by the researcher, trial 2 was dependent on the production of each sound in trial 1. In contrast, if the imitation in trial 1 was correct the researcher would prompt the child to use the sound spontaneously in trial 2. Specifically, if the imitation for the sound in trial 2 was incorrect the researcher would repeat the imitation for trial 2. Similar to the imitation/spontaneous production criteria, if a child was able to produce the sound at the word level in trial 1, they would be prompted to use it at the phrase level in trial 2. However, if they were unable to produce it at the word level in trial 1, then the word level was still targeted in future trials until they could do so accurately. This was important because each child improved at

their own unique rate, thus this system allowed the session to be tailored to the child's level of success.

Homework

Children and their families were asked to complete 5-minute homework assignments for 5 nights per week. Completion of homework was optional but highly encouraged to the caregiver. Every week, each caregiver received a sheet that included 5 sections, where each section was designated for a day of their choosing. In each section, the homework assignment, a description, a spot to write the date and the start/end time of the assignment was listed. Caregivers were provided with a folder each week that contained this sheet along with any materials needed to complete the homework. They were then asked to return the filled-out data sheet the following week when they received a new folder. This system continued for all 6 weeks of the study. No prompting was provided to caregivers to complete homework other than a new folder given to them each week.

Homework consisted of production activities and was dependent on the child's success in treatment. When the child was primarily imitating productions by the researcher, homework was based on more auditory perception activities. For example, children were sent home with a short story that contained the target sound for the caregivers to read to them. As the child began to increase production accuracy and progressed to the spontaneous speech level of the study, homework consisted of more production-based activities. For example, coloring sheets where the child had to name the object to the caregivers or cards with pictures of the target sound and cards without the target sound that had to be sorted into piles. Similarly, homework reflected the linguistic unit being used in the treatment session. If the child was still working on the target sound at the word level, then the homework would practice the target sound at the word level. In

complement, if treatment was primarily targeting the phrase/sentence level, then the homework practice would target the sound in phrases/sentences. Homework only consisted of real words. Examples of homework can be found in Appendix B.

Reliability

For 20% of the cluster and singleton probe data, the researcher transcribed each child's productions for a second time. The second transcription was compared to the original and the number of disagreements was divided by the total number of transcribed sounds. This score was 98.87%, indicating high intra-rater reliability for the transcription of data.

Outcome Measure

There were multiple outcome measures to address the research questions. First, the primary outcome measures were accuracy of the low accuracy sounds on the (1) singleton and (2) cluster probe over the course of the study. The singleton and cluster probes were tested on 2 different occasions during pre-treatment to establish a baseline. They were also tested immediately post-treatment and 4 weeks post-treatment. For both the pre-testing and post-testing, the same pictures and prompts were used to elicit spontaneous responses from the child.

Second, during treatment, smaller probes composed from low accuracy sounds on the singleton and cluster probes were used to monitor progress. On the singleton probe, two words that consisted of low accuracy sounds in the initial position and two words that consisted of low accuracy sounds in the final position were selected for each low accuracy sound. The selected words were divided into two sections (in no specific order) and each section was administered at one of the two sessions that took place that week. Similar to the singleton probe, the low accuracy sounds on the cluster probe were divided into two sections (in no specific order) where

one section was administered during the first session of the week and the other section was administered during the second session of the week.

The third outcome measure was the treatment data that was collected every session. Using the scoresheet (Appendix C), the researcher scored each production of the targeted sound either as correct (+) or incorrect (-). At the end of the session, the researcher would calculate the total percent accuracy from the session and record it into a master spreadsheet.

Lastly, homework completion was tracked in terms of the number of days that homework was completed, average number of minutes spent on homework each week, and total number of minutes spent on homework each week.

Results

The first research question was: Is 6 weeks a sufficient amount of time to use the complexity approach to establish an improved production of a sound that can trigger further change in the sound system? To investigate this, a visual analysis was conducted through several data points, figures were made for each one.

Change During Treatment

Figure 1 plots the data points collected at each session for the target stimulus (i.e. the treated cluster). The x-axis represents different time points from each session over the course of the study and the y-axis represents the overall accuracy by percentage.

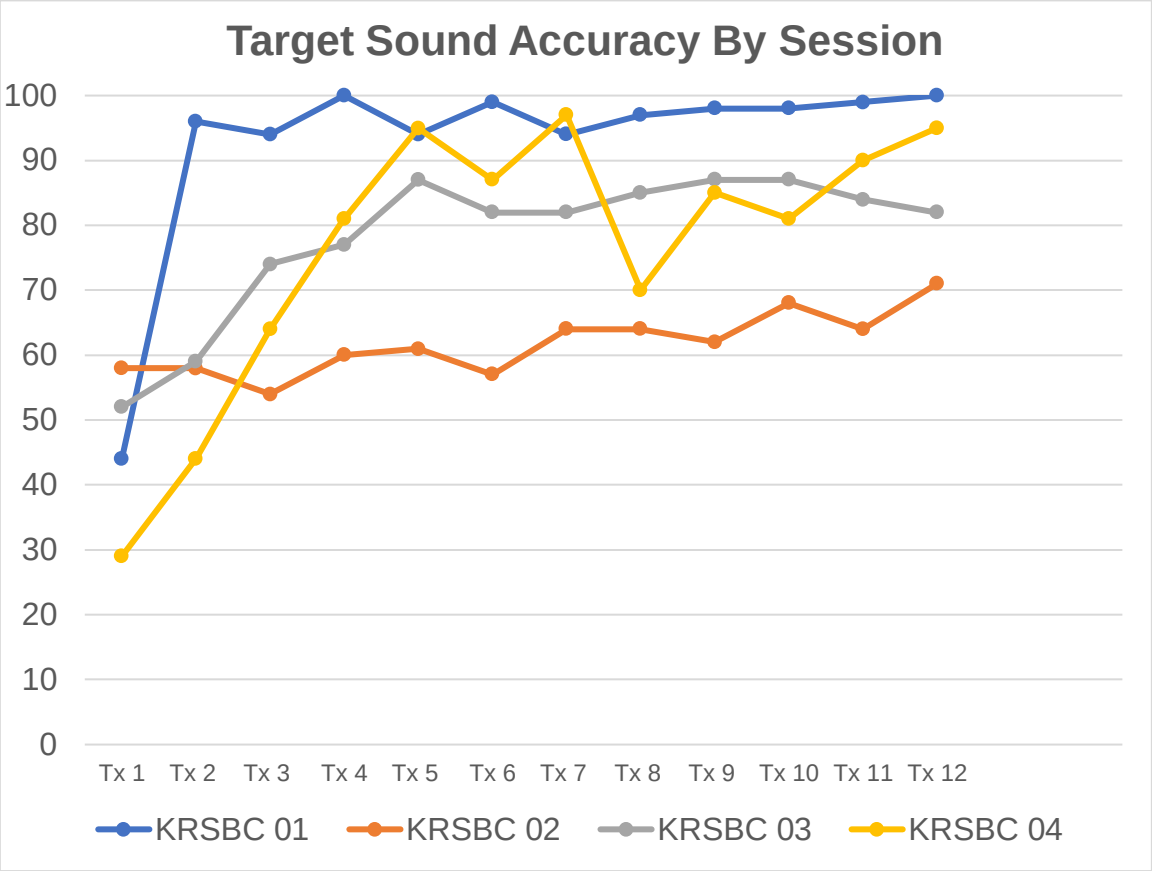

Figure 1.

As seen with KRSBC 01, immediate improvement was observed with production of the target sound. By treatment 2, his accuracy increased 52% and then he maintained improvement over time, even as activities changed. Throughout the session, the difficulty of activities progressed from single-word imitation to spontaneous production at the sentence level. His final accuracy was 100% at the spontaneous sentence level. KRSBC 02 showed slow but consistent growth, ending the study at 71% accuracy at the spontaneous word level. KRSBC 03 showed steady and rapid growth over the first 5 sessions, reaching 87% accuracy by treatment 5 at the imitation word level. Once the activities moved to the spontaneous word level, KRSBC 03's accuracy declined slightly to 82% and continued to remain steady through the course of the

study, ending the study at 82% accuracy at the spontaneous word level. Finally, KRSBC 04 showed steep growth over the first 5 sessions, reaching 95% accuracy at the imitation word level. Session 6 production accuracy declined slightly and then increased once he began working on the spontaneous word level. Accuracy declined at session 8 when activities were based on the imitation sentence level, but then continued to improve, ending the study at 95% accuracy at the imitation sentence level. Overall, children improved their production of their target cluster during session activities with 2 children ending the study at over 90% accuracy, 1 child ending the study at approximately 82% accuracy, and 1 child ending the study at 71% accuracy. These data points show that children were able to improve the accuracy of their target cluster during the study with only 12 treatment sessions.

Generalization: Singletons

Figure 2 plots the data points collected at each session for the singleton production accuracy. The x-axis represents different time points from each session over the course of the study. The first four points are representative of data that was collected during the pre-testing portion. The points labeled “all” represent the accuracy of all of the words from the singleton probe. The points labeled “selected” represent the words that were pulled from the probe that had 0% accuracy after the first pretest. Throughout the treatment portion of the study, the “selected” list was used to probe participants on singleton sounds. The y-axis represents the overall accuracy by percentage. Because the “selected” list was used, overall percentage accuracy was used for easier score comparison.

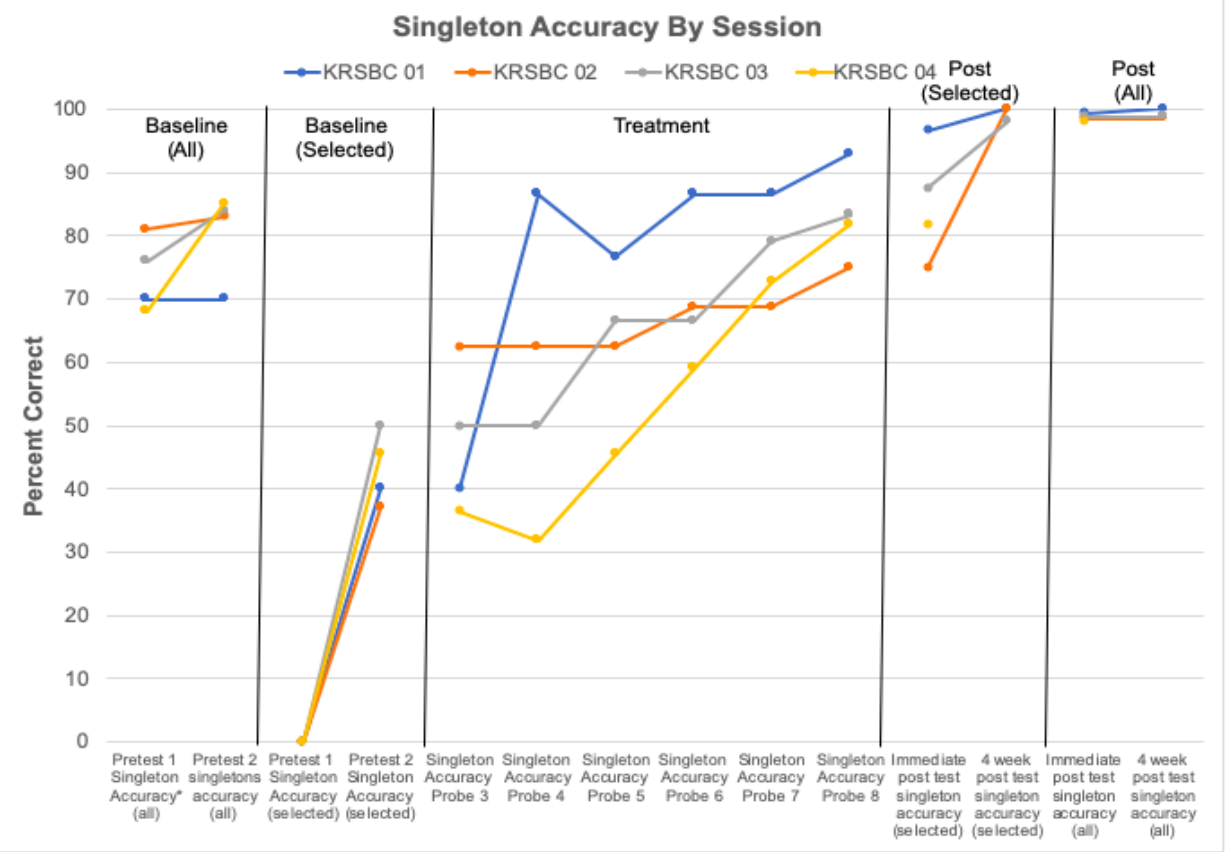

Figure 2.

As seen with KRSBC 01, immediate improvement was observed with overall production accuracy of singletons between probe 3 and probe 4. By probe 4, his accuracy increased 46.6% overall. With the exception of a slight decrease in accuracy during probe 5, his growth was steady. His final accuracy of all the singletons was 99.3% at the immediate post-testing and 100% at the 4-week post-testing. KRSBC 02 showed slow but consistent growth in production accuracy, ending with a final accuracy of all the singletons at 98.6% accuracy at the immediate post-testing and at the 4-week post-testing. KRSBC 03 showed steady and rapid growth in production accuracy, ending with a final accuracy of all the singletons at 98.8% at the immediate post-testing and at the 4-week post-testing. Finally, KRSBC 04 showed rapid growth in

production accuracy across the probes, ending with a final accuracy of all the singletons at 98% accuracy at the immediate post-testing. KRSBC 04 did not have 4-week post treatment data points collected due to the inability to contact their caregiver. Overall, children improved their production of untreated singleton sounds during the study with all children showing 98% accuracy or above by the post test. This suggests that the complexity approach could be effective when used to target a sound in a 6-week period.

Generalization: Clusters

Figure 3 plots the data points collected at each session for the cluster accuracy. The x-axis represents different time points from each session over the course of the study. The first four points are representative of data that was collected during the pre-testing portion. The points labeled “all” represent the accuracy of all of the words from the cluster probe. The points labeled “selected” represent the words that were pulled from the probe that had 0% accuracy after the first pretest. Throughout treatment, the “selected” list was used to probe participants on cluster sounds. The “selected” list included the target sound that each participant was assigned to for the study. The y-axis represents the overall accuracy by percentage. Because the “selected” list was used, overall percentage accuracy was used for easier score comparison.

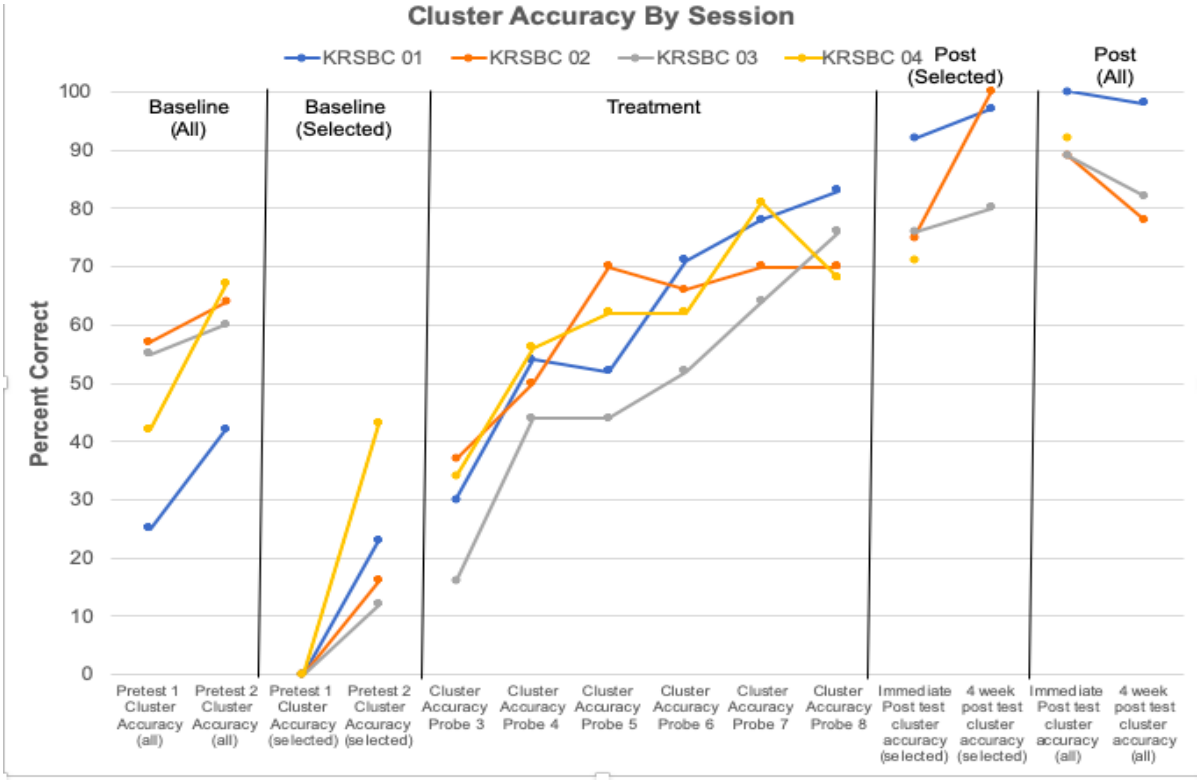

Figure 3.

As seen with KRSBC 01, immediate improvement was observed with overall production accuracy of clusters. KRSBC 01 demonstrated steady growth in terms of cluster production accuracy. His final accuracy of the treated cluster in untreated words and other untreated clusters was 100% at the immediate post-testing and 98% at the 4-week post-testing. KRSBC 02 showed immediate growth until probe 5, reaching an accuracy of 70%. After this, her production accuracy remained steady, ending with a final accuracy of the treated cluster in untreated words and other untreated clusters at 89% accuracy at the immediate post-testing and 78% accuracy at the 4-week post-testing. KRSBC 03 showed immediate and rapid growth in production accuracy, ending with a final accuracy of all the singletons at 89% at the immediate post-testing and 82% accuracy at the 4-week post-testing. Finally, KRSBC 04 showed slow and steady growth in production accuracy, ending with a final accuracy of the treated cluster in untreated words and

other untreated clusters at 92% accuracy at the immediate post-testing. KRSBC 04 did not have 4 -week post treatment data points collected due to the inability to contact their caregiver. Overall, children improved their production of the treated cluster in untreated words and other untreated clusters sounds during the study, with all children scoring at or above 75% accuracy by the 4-week post-test. This suggests that the complexity approach could be effective when used to target a sound in a 6-week period.

In both figure 2 and figure 3, there is a rising baseline between the first and second pretest probe. This indicates that the children improved their sound production on the probed sounds before treatment began. This may mean that children were starting to learn these sounds on their own and may have achieved the same growth without direct treatment.

Homework

The second research question was: Is homework influential on speech sound improvement? To investigate this, a visual analysis was conducted through a table to examine total number of homework assignments completed, average and total minutes spent on homework, and overall accuracy of the target sound for that week. The only participant who completed homework was KRSBC 01, so Table 6 is reflective of that data only.

Table 6

Homework data from KRSBC 01

Week	Accuracy of treatmen cluster production	Number of homework assignments completed	Average minutes	Total minutes
Week 1	S1: 44% S2: 96%	5	6.4	32
Week 2	S3: 94% S4: 100%	5	21.4	107
Week 3	S5: 94% S6: 99%	5	9.6	48
Week 4	S7: 94% S8: 97%	5	11.6	58
Week 5	S9: 98% S10: 98%	2	1.4	7
Week 6	S11: 99% S12: 100%	3	5.3	16

The caregiver reported that some of the homework assignments were repeated multiple times in one sitting because the participant enjoyed doing them and the caregiver thought the assignments helped his articulation. This resulted in some completion times going over the expected five minutes. Although we were unable to do a comparison on the completion of homework due to a lack of participation, completing the homework could have helped KRSBC 01 perform well quickly, improving his accuracy over the first few sessions. KRBSC 01 also maintained high accuracy across sessions compared to the other children who did not complete homework and showed fluctuation in their accuracy across sessions.

Variability Across Children

Table 7 shows the variability between children's data points at the beginning and at the end of treatment. Overall, all participants saw an increase of production accuracy with their treated cluster during sessions, untreated clusters and the treated cluster in untreated words, and untreated singletons in untreated words. KRSBC 01 was the only participant who completed homework, which could provide an explanation for why his improvement in production accuracy across all sounds occurred so rapidly and remained consistent.

Table 7

Sound selection and stimulability[1]

	Sound	% of stimulability	First sound singleton accuracy	Second sound singleton accuracy	Accuracy production of target cluster at tx12	Post singleton accuracy percentage (immediate)	Post cluster accuracy percentage (immediate)	Homework completed?
KRSBC 01	bl	86%	Not tested	90%	100%	99.3%	100%	Yes
KRSBC 02	ʃr	100%	40%	70%	71%	98.6%	89%	No
KRSBC 03	θr	57%	40%	90%	82%	98.6%	89%	No
KRSBC 04	fl	43%	100%	60%	95%	98%	92%	No

[1](Storkel, 2018).

Discussion

Two research questions were addressed in this study: 1) Is 6 weeks a sufficient amount of time to use the complexity approach to establish an improved production of a sound that can trigger further change in the sound system? and 2) Is homework influential on speech sound improvement? Regarding the first research question, results indicated that the program was effective at improving the overall production accuracy on the target sound. All participants saw some degree of improvement between the baseline and post-testing data. In addition to this, it

was observed that the complexity approach was effective in improving accuracy of production of untreated singletons and clusters. Regarding the second research question, results indicated that the one participant who did complete homework, achieved a higher overall production accuracy faster than the other participants and was able to maintain that high production accuracy.

Timeframe

The goal of this study was to complete a treatment program over the span of a summer break in six-weeks, which means it was important to pick targets that were realistic and easier for the participants. Target clusters were selected based on stimulability, accuracy of cluster, and accuracy of singleton sounds that made up the cluster for each participant. This was to ensure maximum results in the short timeframe. If the study were to be replicated, it would be important to pick a target sound in a similar way to ensure that the goal is achievable in the same timeframe.

The lay-out of a drill-based therapy system worked well for this study. The lay-out allowed for sessions to go by quickly which made scheduling easier with caregivers. Additionally, being flexible on location helped with scheduling, as two of the participants were seen at the local library and two were seen in their home. However, being conducted over the summertime did pose some challenges. Two of the participants parents worked during the day and those participants were unable to be seen at daycare, meaning session times were limited to the evening. In addition to this, the family often had sports practices and games to attend in the evening for the participants or their siblings. As a result, their participation in the study began later in the summer until their schedule was more open. This could pose a challenge for someone who has a larger caseload and limited flexibility on time and meeting location.

Participants performed well with the real words and non-words. Introducing the non-words through the storybook helped participants attach meaning to the words, which made them easier to remember through auditory bombardment. However, in the beginning, the participants did need more prompting to help remember the words which caused the productions to be more imitation-based rather than spontaneous. It helped to keep the same 10 words for all of the sessions because participants were able to associate pictures on the flashcards with the word. This made the transition of practicing it on the word level to the sentence level much easier.

Homework

Due to the lack of participation, it is unknown how replicable this portion of the study is. This study demonstrates the difficulties of doing homework and home practice. Although parents were given a packet each week, 75% of the participants did not complete it. This study was an example of a baseline starting point for homework participation and speech services. Caregivers were only given the homework packet each week with the directions to complete what they were able to.

Future Directions and Clinical Implications

If this study was to be implemented, it would be important to follow the protocol for selecting a target sound that is stimulable so that there is the opportunity for maximum results in the timeframe presented. Additionally, the clinician would want to recruit participants in a similar timeframe to this study (i.e. in the spring). Due to confounding factors like mail time, setting up and organizing schedules, and creating materials, it is important to have all participants recruited before the month of May so that the study can begin once the participant begins summer break.

As noted above, figure 2 and 3 indicate a rising baseline. This occurred before treatment sessions began which means that the participants could have been learning these sounds on their own. Due to this, we can't attribute the overall change in sound production to the study. To determine if the rising baseline effected the data, future research would need to complete a second study with a no treatment control group to see if confounding variables played a role in production accuracy during the same time span. This would allow investigators to see how much participants improve during the timeframe in treatment and during the timeframe absent treatment.

Future studies could also explore the possibility of conducting group sessions to look at the effectiveness of this treatment in a group. It would be easier to treat more children in a group setting, but this could pose the risk of having scheduling issues and would not allow for the flexibility of basing the activities on the individual child's progress. Researchers could also explore the different effects that homework has on participants. Our results indicated that the one participant who did complete homework showed faster growth than other participants. Not enough research was done to focus on whether or not this was a large factor in their improvement. Future studies could implement tasks like, requiring homework to continue in the study, sending text/email reminders to caregivers about homework, educating caregivers about the importance of homework in speech therapy before the study begins, providing them feedback on homework, or possibly rewarding the participant and/or their caregiver for completing homework assignments. In addition to this, to determine if homework really was a variable in production accuracy, future studies should conduct the experiment with one group who completes homework regularly and a control group who is not assigned homework.

An implication of this study was the researcher's ability to be flexible due to graduate school requirements. All participants lived at least 20 minutes away and the researcher was taking class and clinicals. If implemented by a full-time SLP, scheduling might be easier due to more flexibility and geographic location.

Conclusion

This study suggests that a short-term summer program using the complexity approach may help children with mild-to-moderate articulation deficits rapidly improve their speech production prior to the start of Kindergarten. This could help decrease the number of children with SSD on SLP caseloads in elementary schools.

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Appendix A

Nonsense Word Story Script

1. Once upon a time, there was a little girl named **Blid**. **Blid** was three-years-old. Her best friend was **Bloop**. She loved to play with her **blanket** and **Bloop**.
2. Her **Bloop** had green fur and horns red as **blood**. They had been friends forever.
3. They liked to play together every day! Sometimes they would **blow** bubbles outside! One day they were sitting and talking and **Blid** told **Bloop**, "There is a toy I really, really want."
4. It's a **blan**. A **blan** is a beautiful **blue** color and it is smooth and can spin.
5. So, **Bloop** decided that he would find it for her.
6. He went to the **blug**. He thought "Surely I can find it at the **blug**. The **blug** has everything you could ever think of! But no. The **blug** did not have it! All **Bloop** could find at the house was **bleach**. He said "I will keep looking!" With that, he left the **blug**.
7. He decided to take a **blef** to the mall. Surely the mall will have it! He walked down to the **blef** stop and waited for the **blef.** The **blef** showed up. He jumped into the **blef** and headed down the road.
8. At the mall, he went in every store looking for the **blan**. Ha! There it is! He found the **blan**! He was so happy!
9. **Bloop** ran straight home and gave the **blan** to **Blid**. **Blid** was so happy!

Use this table and the corresponding slides for individual practice. Most likely you will want to print hard copies of the slides (possibly the 6 slides per page handout) and laminate them. Slide 7 and 8 are only used in the story and is not needed for individual practice.

Slide #	Meaning	NSW	Real words	Picture Source
1	[girl's name]	Blid	Blanket	Pixabay
2	[toy name]	Blan	Blood	Pixabay
3	[monster's name]	Bloop	Blow	Pixabay
4	[hobbit house]	Blug	Blue	Pixabay
5	[rickshaw]	Blef	Bleach	Pixabay

Appendix B

KRSBC 01 homework week 2

Homework #1: Blo the Bird story **Time Start:**_____**Time End:**_____

Have your child color in the pages on the book. While they are coloring, talk to them about the page and hae them say words back to you. (i.e. "You are using the BLue crayon to color in her BLouse". Once the child has finished coloring in the pages, fold the book and read it to them, placing emphasis on the words that are underlined.

Homework #2: /bl/ Coloring sheet **Time Start:**_____**Time End:**_____

Have your child color in the picture. As they are coloring in, read the words on the page to them. Then have them repeat the words back to you.

Homework #3: Pirate box **Time Start:**_____**Time End:**_____

Cut out the pictures and say them 5 times, then tape it onto the treasure chest.

Homework #4: Songs **Time Start:**_____**Time End:**_____

Song 1: Barney – My Yellow Blanky (SONG)
https://www.youtube.com/watch?v=0GD7UNaonB0

Song 2: Sesame Street: Fuzzy and Blue https://www.youtube.com/watch?v=2NSdNtOktHE

Homework #5: Rhyming Words **Time Start:**_____**Time End:**_____

On the attached sheet, there are 10 words that start with the /bl/ sounds. Have your child think of 1 rhyming word for each sound that does not start with bl! (ex/ blue and clue)

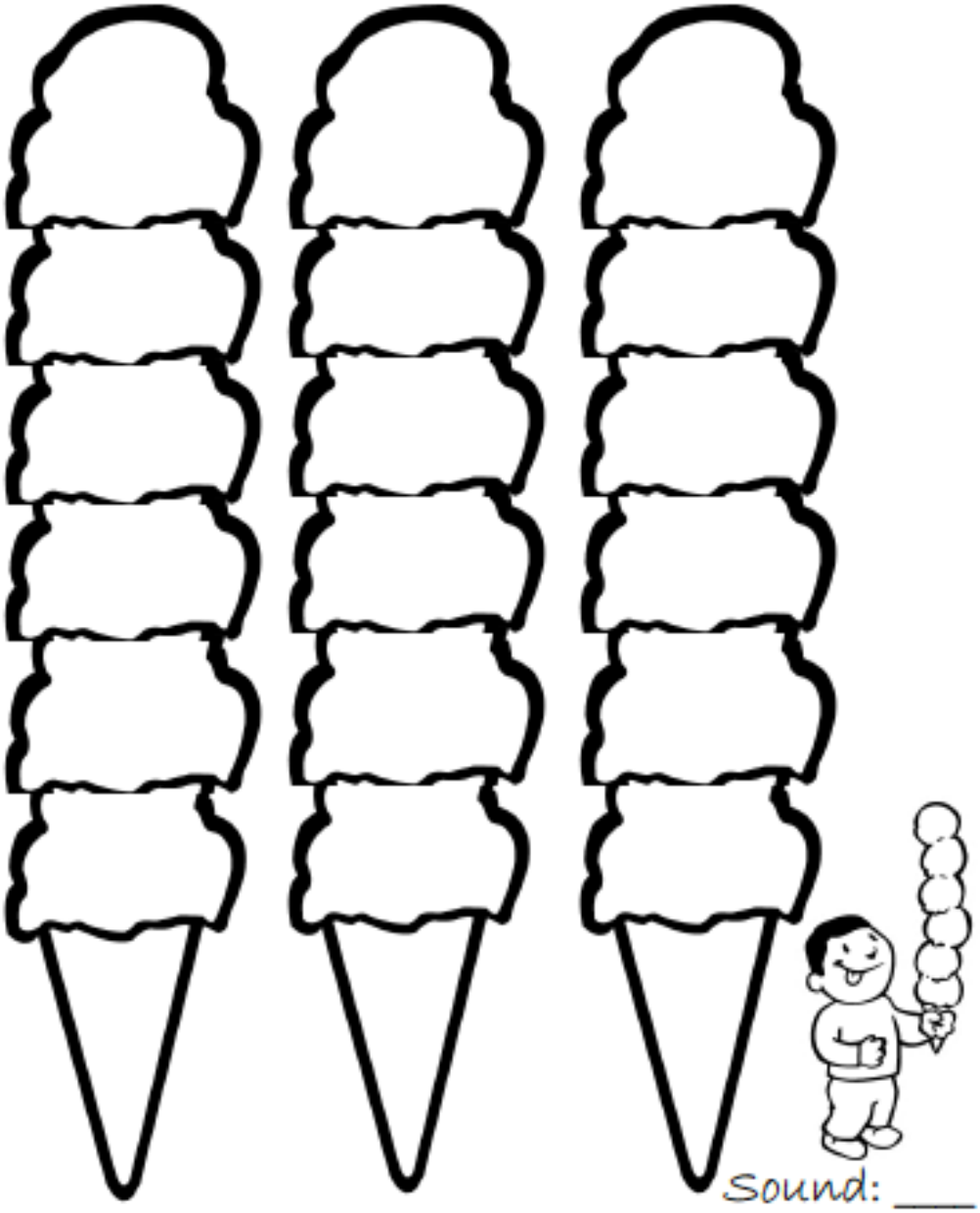
Name: _____ **Homework Helper Initials:** _____

Say your speech sound: ___ in words 3x ___ in the phrase below ___ in a sentence
___tell your homework helper a story using as many as you can

Color each scoop of ice cream after you've finished practicing that word!

I scream! You scream! We all scream for ice cream!

Phrase:



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Artic **Treasure**

Hunt for words with your speech sound. Write a word on each gold doubloon.
___ Say each word 5 times. ___ Say each word in a sentence.

Helper Signature: _____

Rhyming words:

1. **Blue**
2. **Bloom**
3. **Bleach**
4. **Blow**
5. **Bliss**
6. **Blink**
7. **Blame**
8. **Blare**
9. **Bland**
10. **Blog**

Appendix C

Word	Trial 1 W/Ph Im/Sp	Trial 2 W/Ph Im/Sp	Trial 3 W/Ph Im/Sp	Trial 4 W/Ph Im/Sp	Trial 5 W/Ph Im/Sp	Trial 6 W/Ph Im/Sp	Trial 7 W/Ph Im/Sp	Trial 8 W/Ph Im/Sp	Trial 9 W/Ph Im/Sp	Trial 10 W/Ph Im/Sp
Blue										
Bleach										
Blood										
Blow										
Blanket										
Blid										
Blan										
Blug										
Blef										
Bloop										
	__/10	__/10	__/10	__/10	__/10	__/10	__/10	__/10	__/10	_/10