EFFECTIVENESS OF SYSTEMATIC ARTICULATION TRAINING PROGRAM ACCESSING COMPUTERS (SATPAC) APPROACH TO REMEDIATE DENTALIZED AND INTERDENTAL /S, Z/:
A PRELIMINARY STUDY1,2

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Summary.—Traditional methods for treating speech distortion errors in older school-age children have tended to yield mixed success. The current study was a preliminary evaluation of an alternative approach called the Systematic Articulation Training Program Accessing Computers (SATPAC), which was tested for the remediation of /s/ and /z/. Procedures involved a sequence of phonetic placement and/or oral-motor placement cues as needed to establish the targets, followed by concentrated drill structured around a facilitating context nonsense word and then advanced to more natural contexts. Participants were 18 children aged 6 years, 9 months to 11 years, 10 months. Treatment involved once per week, individual, 10-min. sessions with an experienced speech-language pathologist. Group A (n = 9) received 15 weeks of treatment, while treatment was delayed for Group B (n = 9). Then the groups were reversed. During period one, Group A (treated) significantly improved their accuracy of /s, z/ in spontaneous speech, while Group B (untreated) showed no significant change. During period two, Group B improved significantly when treatment was applied. The majority of the participants retained proficiency two years later.

The phonemes /s/ and /z/ are among the English sounds on which errors are most often made (Bleile, 2006) and the most common targets in school therapy (Porter & Hodson, 2001). Dentalization of these sounds is the most common English production error (Shriberg & Kent, 2013, p. 154). Such errors likely have minimal impact on intelligibility, but Crowe Hall (1991) found that children who produce them may be viewed by their peers more negatively, i.e., as less smart, less interesting, and speaking less well than their typically-speaking peers. Clinicians anecdotally report some success correcting these errors, but carryover and maintenance

1Address correspondence to Dr. Jean Neils-Strunjas, Armstrong Atlantic State University, …. 2Stephen Sacks is the developer of the SATPAC program and software and has a financial interest in the software. The first authors would like to express sincere thanks to M. N. Hegde for helping with the design of the study and with editing, to Connie Jones for doing statistical calculations, to Jody King, Elin Oppliger, and Carolyn Johnson for interjudge reliability measures, to Jennifer Taps as a valuable source for references, to Barbara Owen for her helpful comments, and to Jennifer Gray for her editing.
remains a considerable issue (Ruscello, 1995a). Formal studies of the traditional approaches most often used with these errors have yielded mixed success (e.g., Klein, 1996).

A major goal of therapy is to change the child’s speech in an efficient manner (i.e., with minimal overall effort). Given this goal and the limited effect on intelligibility, it is not surprising that anecdotal reports suggest that older children with only one or a few speech sound errors receive as little as 15 minutes of individual therapy per week. Given that the amount of time in therapy has been shown to be directly related to the amount of improvement (Jacoby, Levin, Lee, Creaghead, & Kummer, 2002), such limits on therapy time may be a major reason for the inconsistent speech treatment outcomes in older children currently being observed.

With busy caseloads it is unlikely that more therapy time will become available. This would suggest that perhaps a different approach is necessary. One proposed strategy has been to modify the type of external feedback provided to the child. Several methods have been proposed including electropalatography (e.g., Gibbon & Wood, 2010), intra-oral appliances (Ruscello, 1995b; Rogers, 2010), ultrasound (Adler-Bock, Bernhardt, Gick, & Bacsfalvi, 2007), airflow displays (Ruscello, 1995a), computer-judged goodness of match plus visual imagery feedback (Pratt, Heintzelman, & Ensrud Deming, 1993), or spectrograms (Shuster, Ruscello, & Toth, 1995). Some success has been reported, but available findings tend to be either based on very small samples (often single participants) or low-level study designs. More importantly, upfront and/or ongoing costs and the required training associated with most of these solutions may render them impractical in many settings.

Another strategy for making better use of the available time may be to change the organization of the training stimuli. Skelton and colleagues have proposed “concurrent treatment.” Unlike conventional treatment, where practice progresses across linguistic levels in a specific order (e.g., isolation to syllables to words to sentences to conversation) with specific criteria for progression from one level to the next, Skelton suggested that the different levels could be presented randomly. For example, the child might be asked to produce the target sound at the sentence level, then the word level, and then the conversation level, all in rapid succession within the same therapy session (see Skelton, 2004, p. 139, for an example). Preliminary efficacy findings have been reported with two to four participants (e.g., Skelton, 2004; Skelton & Funk, 2004).

Systematic Articulation Training Program Accessing Computers

The intervention approach studied herein is another alternative to making better use of available therapy time. The Systematic Articulation
Training Program Accessing Computers (SATPAC) is based around the idea of changing the nature of the stimuli being used for therapy practice. In particular, it makes use of nonsense words. Such words have long been included in traditional articulation programs in a limited way (Van Riper, 1978). However, most current speech sound intervention programs do not use them because of the close interdependence of articulation and language development, and because very young children often have difficulty relating to them. For older school-aged children, their use is less likely to be a problem. The SATPAC approach assumes that nonsense words may be helpful for breaking habitual patterns of misarticulation in long-practiced real words. They may also allow the child to focus their attention on the motor aspects of articulation (Gerber, 1973).

In addition to nonsense words, the SATPAC approach includes three other key elements. The first key element is use of the long-established notion of facilitating phonetic contexts for consistency of production and to promote generalization both to phonetically similar contexts and to a wide variety of other phonetic contexts (McDonald, 1964a; Kent, 1982; Secord & Shine, 1997b). For example, the /t/ sound may be facilitative of correct /s/ production (Bleile, 2006). With SATPAC, the child progresses systematically from production in simple facilitating phonetic contexts into correct production in more complex combinations reflecting multiple phonetic variations. This approach also builds on the idea of co-articulation (McDonald 1964a; 1964b), in which practice in multiple contexts approximates conversational speech more so than isolated word practice. Generalization to more natural contexts is thus incorporated at a very early stage.

The second key element of the SATPAC approach is the systematic nature of the practice. Initially, minimal changes are made from word to word, building on the facilitating context (e.g., beetseek, mitseek, weitseek, etc.). This is intended to encourage the development of a consistent motor pattern for the targeted sound (Sacks & Shine, 2004).

The final key element of the approach involves using appropriate speech rate. The ultimate goal of intervention should be correct production at normal rates (Gerber, 1973) and developing correct production skills that are more automatic (Hewlett, 1990). The typical strategy of slowing down the child’s speech may actually hinder automaticity. Normal rate is incorporated by systematically building up to slow conversational rates that incorporate natural speech components such as natural prosody. As with most other motor approaches, SATPAC requires that the child can produce the correct phonetic placement of the sound. If he or she cannot, then the placement is taught through such methods as verbal description, demonstration, physical manipulation, visual and verbal feedback.
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(Secord, Boyce, Donohue, Fox, & Shine, 2007), and any supplementary, less-traditional technique the clinician finds helpful. One such less-traditional approach was used in the current study.

Once correct placement has been established, three specific treatment phases follow: (1) Establishment, systematic use of the target sound through seven steps using one facilitating context nonsense word; (2) Intratherapy Generalization, systematic use of the target sound in a nine-list hierarchy of nonsense words in multiple phonetic contexts; and (3) Transfer, use of the target sound in real words phrases, sentences, reading (if appropriate), and conversation. The program included a combination of features which increased the automaticity of the correct sound productions: 10-min. treatment sessions with high rates of production practice and practice of /s/ and /z/ in two-syllable nonsense word contexts with varied stress patterns, prior to transitioning to real words.

The SATPAC Program Software generates specific, hierarchical target lists going from easy to more difficult productions. Specific sounds or error patterns can be remediated using facilitating contexts in these systematic lists. The use of facilitating contexts in 100% of productions (e.g., /ts/ to facilitate /s/) of the nonsense words is reduced by List 6 of the Intratherapy Generalization Phase (see Appendix). It is at this point that the participant uses the target sound in various phonetic contexts (i.e., /ps/, /fs/, /ks/, etc.).

Current Study

The Office of Research Control—Research, Evaluation and Assessment of the Fresno Unified School District approved this study. The children in the current study attended an elementary school with a high percentage of students who are economically disadvantaged (>80%). It has been suggested that socioeconomic status (SES) may interact with other factors such as otitis media (Shriberg, Flipsen, Thielke, Kwia-Kwiatkowski, Ker-toy, Nellis, et al., 2000) to increase the risk of speech sound disorders; however, a recent review by Bernthal, Bankson, and Flipsen (2013) suggested that “… speech sound disorders are not that strongly associated with low SES…” (p. 175). Low SES should not necessarily reduce the likelihood of treatment success. Given that this population would be less likely than those of higher SES to be able to access private therapy services, it was judged important to know whether children could benefit from a reasonable modification to available school-based services.

Another important aspect of the current study was the fact that six of the 18 participants were bilingual speakers, with three different first languages represented (Hmong, Khmer, and Spanish). Similar to SES, treatment studies have tended to be limited to monolingual English speakers;
inclusion of bilingual speakers might be justified. It is noteworthy, however, that the particular second languages spoken were judged likely to have little or no effect on outcomes, because this particular study focused on /s/ and /z/ errors. In Spanish and Khmer, there is an /s/ sound similar to English with placement in the lingua-alveolar position. Hmong has no /s/ sound. Perhaps most importantly, in all three of these languages, there are no interdental sounds like /θ, δ/, suggesting that any observed dentalized or interdental placement for /s/ and /z/ would be an error and not be due to interference from the participants’ other languages.

**Research Question.**—Was the SATPAC approach using 10-min. sessions once per week for 15 weeks a successful method for treating dentalized or interdental productions of /s/ and /z/?

**Method**

**Participants**

The 18 participants (11 boys, 7 girls) were from Fresno, California and were between the ages of 6:9 (years:months) and 11:10 (\(M = 8:6; \text{Mdn} = 8:4\)). Participants were selected based upon teacher referral and classroom screening for dentalized or interdental productions of /s/ and /z/. Dentalized productions of these phonemes result in a distorted acoustic signal (i.e., they sound slightly atypical), and interdental productions may or may not sound correct but the tongue protrusion may create visual confusion for the listener as to whether /s, z/ or /θ, δ/ was intended. The majority of the participants (\(n = 13\)) were selected from a year-round school, and five were selected from a school on a traditional schedule. Children from minority backgrounds were the majority in both schools. The year-round school included 72% Hispanic, 15% Asian, and 9% African-American children with 88.2% classified as socioeconomically disadvantaged. The traditional school included 58% Hispanic, 8% Asian, and 20% African American with 84.3% classified as disadvantaged. A majority of the participants (\(n = 14\)) were selected from second and third grade classes, with the remainder (\(n = 4\)) identified from Grades 4 to 6.

All Grade 2 and 3 classes were screened in groups of three by the school Speech-Language Pathologist (SLP) for production of /s/ and /z/ in conversational speech, in the SLP’s office. Possible participants were further evaluated using the Assessment Link between Phonology and Articulation-Revised (ALPHA-R) (Lowe, 1995). Following identification, parents were approached for informed consent to have their child participate in the study. Ten of the 18 participants also displayed other speech sound errors (four from Group A and six from Group B) (see Table 1).

The use of the single word productions from the ALPHA allowed for data collection to include both conversational speech and single word pro-
<table>
<thead>
<tr>
<th>ID</th>
<th>School Type</th>
<th>Group</th>
<th>Agea</th>
<th>Sex</th>
<th>Languages spokenb</th>
<th>Other Speech Errorsc</th>
<th>Treatment, Min.</th>
<th>ALPHA Errors</th>
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<tr>
<td>1</td>
<td>Year Round</td>
<td>A</td>
<td>6:11</td>
<td>f</td>
<td>Spanish, English</td>
<td>/θ, δ,/</td>
<td>150</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Year Round</td>
<td>A</td>
<td>8:7</td>
<td>m</td>
<td>Khmer, English</td>
<td>None</td>
<td>150</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Year Round</td>
<td>A</td>
<td>8:8</td>
<td>m</td>
<td>Hmong, English</td>
<td>/θ, δ, r/</td>
<td>150</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>Year Round</td>
<td>A</td>
<td>7:0</td>
<td>m</td>
<td>English-only</td>
<td>/θ, δ/</td>
<td>150</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Year Round</td>
<td>A</td>
<td>6:10</td>
<td>m</td>
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<td>None</td>
<td>150</td>
<td>11</td>
</tr>
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<td>A</td>
<td>8:7</td>
<td>m</td>
<td>English-only</td>
<td>None</td>
<td>150</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>Year Round</td>
<td>A</td>
<td>11:8</td>
<td>f</td>
<td>English-only</td>
<td>None</td>
<td>100</td>
<td>11</td>
</tr>
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<td>8</td>
<td>Traditional</td>
<td>A</td>
<td>8:2</td>
<td>f</td>
<td>English-only</td>
<td>/θ, δ/</td>
<td>150</td>
<td>15</td>
</tr>
<tr>
<td>9</td>
<td>Traditional</td>
<td>A</td>
<td>8:11</td>
<td>f</td>
<td>Spanish, English</td>
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<td>120</td>
<td>11</td>
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<tr>
<td>10</td>
<td>Year Round</td>
<td>B</td>
<td>8:5</td>
<td>m</td>
<td>Hmong, English</td>
<td>/θ, δ/</td>
<td>150</td>
<td>15</td>
</tr>
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<td>11</td>
<td>Year Round</td>
<td>B</td>
<td>9:1</td>
<td>f</td>
<td>English-only</td>
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<td>11</td>
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<td>m</td>
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<td>/θ, δ/</td>
<td>70</td>
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<td>6:9</td>
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<td>/θ, δ/</td>
<td>150</td>
<td>13</td>
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<tr>
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<td>B</td>
<td>7:8</td>
<td>m</td>
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<td>/θ, δ/</td>
<td>150</td>
<td>15</td>
</tr>
<tr>
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<td>B</td>
<td>11:10</td>
<td>f</td>
<td>English-only</td>
<td>None</td>
<td>150</td>
<td>11</td>
</tr>
<tr>
<td>16</td>
<td>Year Round</td>
<td>B</td>
<td>7:7</td>
<td>f</td>
<td>Hmong, English</td>
<td>None</td>
<td>150</td>
<td>4</td>
</tr>
<tr>
<td>17</td>
<td>Year Round</td>
<td>B</td>
<td>7:4</td>
<td>m</td>
<td>English-only</td>
<td>/tʃ, θ, /dʒ, θ, δ/</td>
<td>150</td>
<td>27</td>
</tr>
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<td>18</td>
<td>Year Round</td>
<td>B</td>
<td>7:10</td>
<td>m</td>
<td>English-only</td>
<td>/r/</td>
<td>150</td>
<td>21</td>
</tr>
</tbody>
</table>

Note.—aExpressed in years; months. bFirst language spoken outside of school listed first. cNot targeted in the therapy program.
ductions (a recommended practice; Bernthal, et al., 2013). Raw scores (i.e., number of errors) for each participant on the ALPHA are shown in Table 1. As indicated all participants were producing errors at the single word level.

Children selected had no reported history of hearing loss or documented language or learning disorder. The participants were not identified as having language impairment as part of the school screening process. None of the children failed the school hearing screening. None had been previously identified as having a speech sound disorder nor had received any speech intervention. Six participants (four from Group A) were bilingual speakers. Three of the bilingual speakers spoke Hmong (from Laos), one spoke Khmer (from Cambodia), and two spoke Spanish. As discussed previously, these languages were judged to pose little to no interference threat with the speech sounds being targeted. All six bilingual participants were judged informally by their teachers and the school SLP to be proficient in spoken English. All produced misarticulations both by standardized assessment and in informal comparison to other students in their schools from similar language backgrounds.

Assignment to the treatment groups was done quasi-randomly due to school scheduling issues. Eight participants from the year-round school were assigned to Group A, and six were assigned to Group B. The first two participants from the traditional schedule school were assigned to Group A, and the final three were assigned to Group B. Once assigned, Group A included five boys and four girls; Group B included six boys and three girls. At initial testing, the two groups did not differ significantly on age (Mann-Whitney p > .99, or on percent correct productions of /s/ and /z/ in conversational speech (Mann-Whitney p = .29). By the end of the study, the two groups also did not differ on mean minutes of treatment provided (Mann-Whitney p = .89). Two-year follow-up data were available for 16 of the 18 participants.

**Treatment**

All treatment sessions were conducted individually by the first author, an experienced SLP. Sessions were 10 min. long and occurred once per week for 15 weeks. After each session, an activity or a list of words similar to what was targeted in intervention or had been practiced successfully in a previous session was given to the student to practice at home for the week. This was intended to build or reinforce the skill that they were working on in therapy. If competence was not shown in the therapy session for a particular skill or list of words, homework was provided at the level where they did show competence.

The basic outline of the SATPAC sequence is shown in the Appendix. The first three parts of treatment (placement, establishment, intratherapy
generalization) targeted only /s/. Treatment in the last phase of treatment (Transfer) targeted both /s/ and /z/.

**Pre-Treatment: Correct Placement**

Treatment to correct the dentalized or interdental misarticulations /s, z/ began by teaching correct placement using phonetic placement cues, oral-motor placement cues, or both. For the current study a specific (non-traditional) approach was utilized. The procedure assumes that producing both /s/ and /z/ phonemes requires correct tongue-tip placement as well as correct positioning of the posterior lateral margins of the tongue. Independent control (i.e., differentiation) of the two regions of the tongue has been suggested as being crucial to learning correct production for some children (Rosenfeld-Johnson, 2001). To allow for differentiation, the jaw was stabilized using an infant tongue depressor (somewhat analogous to the ‘bite stick’ used by Shriberg, 1980) between the top and bottom side teeth.

Correct production of /s/ was then facilitated by shaping from /i/, a long-cited facilitating context (Secord, et al., 2007). A mirror and flashlight were used for visual feedback. Participants were instructed to say /i/, and then point the tongue tip at the alveolar ridge while maintaining contact between the sides of the tongue and the back teeth. Typically, participants would tend to drop the entire tongue and move it forward.

If the above procedure did not yield the desired differentiation, the investigator placed an applicator stick on one lateral margin of the tongue near the back molars. Participants were instructed to keep the lateral margin of the tongue against the stick. Correct positioning was confirmed using the mirror and flashlight. Participants who continued to struggle with stabilizing the back of the tongue while moving only the tip to the alveolar ridge were instructed to use the vowel /i/ and then pop their tongue. The “pop” was created by a sucking action that resulted in the release of a pocket of air enclosed by the tongue. Although technically not a true speech movement, its use here was intended only to help establish correct tongue-tip placement. With visual feedback from the mirror, each participant could see when he or she placed the tongue tip correctly in the lingua-alveolar area and kept the sides of the tongue wide against the upper back molars. Participants were asked to practice this step for a week during daily homework of 50–100 repetitions. Each participant developed the skill within one week.

Participants were then asked to say /i/ and prepare to pop their tongue, but stop just before doing so. The net result was an /i/-point, moving the tongue tip into the lingua-alveolar area and paying attention to the tongue-tip movement while the back of the tongue remained stabilized on
the back molars. Participants were also instructed to close their eyes and make the same movement receiving only tactile-kinesthetic feedback.

Participants were then instructed to make contact with the tongue tip against the alveolar ridge using /t/ and say /i-t/ (Bleile, 2006), producing a gentle /t/. The goal was complete posterior/anterior differentiation of the tongue with no associated lip or jaw movements. This production of /it/ with the mouth open (a posture resulting from the presence of the tongue depressor) is not the correct jaw position for either /i/ or /t/. The purpose was to allow visual feedback of the tongue movement that can only be seen with the mouth open. There was some variability in how long it took to reach this criterion as measured from the initial therapy session. One participant met it in one session, but another required eight sessions. The majority of the participants (13/20) met the criterion after two to five sessions.

To transition to the nonsense word facilitating contexts, each participant was then asked to say /its/ (VCC) by producing /it/ while “lengthening the duration” of the /t/ sound (Secord, 1985); this was demonstrated by the clinician. For this step, the infant tongue depressor was removed and the teeth were allowed to close in a natural resting position. This was intended to serve as a facilitating context for /s/ based upon the positioning of the articulators for the /i/ and /t/ sounds. Participants were told that they were practicing a “French /t/” (Secord, et al., 2007; Winitz, 1975), a strategy intended to help prevent the emergence of their habitual error. This approach facilitated correct /s/ production for all participants. The students transitioned from /its/ to /its-i/ to /bits-i/ to bits-ik/to/bitsik/ and then began the Establishment Phase.

Phase 1: Establishment

The clinician modeled the word /bitsik/ as the facilitating context keyword for /s/. The /i/ phoneme widens the tongue and anchors it against the upper back molars. The /t/ places the tongue tip in the correct lingua-alveolar position that when frictionalized (by prolonging the release of /t/) becomes a correct /s/. The following /i/ keeps the tongue in the lingua-alveolar position followed by the /k/, which facilitates posterior movement of the tongue, discouraging an interdental lingual production (Kent & Minifie, 1977). Four participants had difficulty with /bitsik/ and their facilitating context words became/bissit/, /bitsit/, or /biksik/.

Only step 3 of the Establishment Phase (see Appendix) was used in the current study because the participants appeared to develop competence saying the keyword by initially practicing smaller units of it (i.e., /its/, /itsi/, /bitsi/) and then eventually the entire keyword. Participants
were required to say their target nonsense word correctly with 95% accuracy for 20 productions (i.e., 19/20 correct) at no specific prescribed speaking rate before they progressed to the next phase.

Phase 2: IntratheraPY Generalization

Participants then progressed to the nine lists tailored to each participant's unique sound inventory using the computer program (see Appendix for some examples). Sounds that interfered with the target /s/ (e.g., /θ/) or were not in the participants' repertoire (e.g., /r/) were eliminated. Eight lists of CVCCVC nonsense words were presented, with each list systematically moving further and further away from the facilitating context keyword until the /s/ sound was produced in many varied phonetic contexts. List 9 is a contrastive stress sentence list using random CVCCVC nonsense words from the previous eight lists in a series of sentences containing real words (i.e., the sentence includes real words except for the target nonsense word).

All 20 target words and sentences from each list were modeled first by the investigator and repeated by the participant. In addition to simple auditory repetition, systematic rate modifications were drilled (Gerber, 1973) using an external metronome to initiate and monitor the rate of speech for each word. If the participant showed initial competence, lists were presented at 140 beats per minute (bpm). If competence was a problem, the starting rate for each list was reduced to 100 bpm, with rate increasing in 20 bpm steps up to a slow conversational rate of 140 bpm when necessary. Rate was increased when the participant attained 80%+ accuracy at that rate (i.e., at least 16/20 correct). At the 100 and 120 bpm rate, a two-beat pause was introduced between items to allow the participant time to process the nonsense word and generate their response. At the 140 bpm rate, a four-beat pause was inserted. Each participant was required to achieve 80%+ accuracy at 140 bpm before progressing to the next list.

For List 9, participants were required to repeat the first modeled sentence from the contrasting stress list (e.g., “A boy bought a new/bitsik/”). The investigator then asked a contrasting sentence (e.g., “I bought a new /bitsik/?” with emphasis on the word “I”). The participant would reply with the correction (e.g., “No, a boy bought a new/bitsik/”) emphasizing the word that the investigator changed. The investigator then changed the verb (e.g., “A boy sold a new/bitsik/?”) and the participant would reply with the correction (e.g., “No, a boy bought a new/bitsik/”). This turn taking routine was repeated for each sentence with four questions per sentence. The metronome was not used on List 9. Rate was expected to be the same slow conversational rate as for the other lists and was judged subjectively.
Success on this phase was met when participants achieved the 80% criteria in the eight practice lists at the slow conversational rate (140 bpm) and 80% on List 9. Participants took one to eight (Mdn = 5) sessions to reach this criterion.

Phase 3: Transfer

Because self-monitoring outside of therapy is a critical component of external generalization or transfer (Koegel, Koegel, Voy, & Ingram, 1988), participants were then given a mechanical tally counter for home practice to count correct productions (Nelson & Hayes, 1981). Participants were allowed a trip to the “Goodie Box” (i.e., a box of small trinkets) for returning a homework paper with at least 100 correct productions for a minimum of five of the seven days of the week.

The Transfer phase began using the SATPAC Phrases for /s/. Targets in this phase were now real words. When the participants achieved 75% accuracy (Secord & Shine, 1997a) with a slow conversational rate (subjectively judged), they proceeded to the SATPAC Short Sentences for /s/ (with a pre- and post-vocalic /s/ in each sentence with the introduction of some /z/ sounds), and finally the SATPAC Sentences for /s/ (three or more /s, z/ sounds per sentence).

Children who achieved mastery (75% or higher accuracy) on these latter activities proceeded to a series of generalization activities. These included reading and answering questions from classroom reading texts for the fluent readers or conversations about classroom stories or what was happening in their lives. A tally counter was kept in the treatment room for the participants to use during all activities. If a participant appeared to be slowing down due to use of the tally counter, the investigator used the counter to help ensure that a conversational rate was maintained.

Therapy Pace and Feedback

During the 10-min. treatment sessions, the correct number of responses ranged from 20 to 200, with low numbers occurring at the beginning of the study when participants were establishing correct /s/. A typical session during Phase 2 would have approximately 80 correct responses with the participant completing four lists. Highest response counts occurred during Phase 3 when the contrastive stress technique evoked more responses in a shorter time.

When errors occurred, the participant was given verbal (e.g., “you said/bitθik/”), visual (e.g., a model of the error-/bitθik/ with exaggerated duration of tongue protrusion), or nonverbal (e.g., a pause with no verbal or visual feedback) feedback. Intermittent positive verbal reinforcement was used for correct productions during all phases (e.g., “good”—“nice”) beginning with the placement activities. Positive verbal reinforcement was always given when participants self-corrected.
Dismissal criterion was set at 75% correct (Secord & Shine, 1997a) during normal rate conversation. Four participants met this criterion for four consecutive weeks prior to the culmination of the 15-week program and were dismissed early. All remaining participants were working on Phase 3 by the end of the 15 weeks.

Data Collection

Data to evaluate progress were derived from video samples obtained at Time 1, Time 2, Time 3, and two-year follow-up. At each evaluation point participants were videotaped in the SLP office of their school using a Canon ZR80 Digital Video Camcorder with a built-in microphone. Participants were seated approximately 3 feet from the camera. The recordings were formatted using the Roxio Videowave Program and viewed for the analysis using Windows Mediaplayer.

Pre-treatment and post-treatment evaluations were conducted by the first author and were based on production of phrases from the SATPAC Transfer Phase list for /s/ and a conversational speech sample. Each phrase contained a prevocalic and postvocalic /s/ with an /s/ from each phrase systematically abutting against every consonantal phonetic context (e.g., soft whisper (postvocalic /s/ abutting against /p/), knapsack mess (prevocalic /s/ abutting against /p/)). Follow-up evaluations were also conducted by the first author and consisted of conversational speech samples only. At the beginning of the study, all of the participants exhibited errors on /s/ and /z/ in both phrases and conversation (Table 1). Five of the 18 participants had at least one correct /s/ and /z/ in some context before the treatment procedures were applied.

Reliability of scoring was carried out by two experienced speech-language pathologists who had not been present for any of the assessment or treatment sessions. Re-evaluations were done on 42% (23/55) of the recorded spontaneous conversation samples obtained from the pre-treatment (8/19), post-treatment (8/19), and follow-up (7/17) sessions; the samples were evaluated using the video recordings transferred onto CDs. Average interjudge reliability (point-to-point method) was 100% when evaluating the pre-treatment sessions, 96.1% for the post-treatment sessions, and 94% for the two-year follow-up sessions.

Procedure and Analysis

All 18 participants were evaluated at Time 1. Nine participants (Group A) began the 15 weeks of treatment immediately, while treatment was delayed for the other nine (Group B). Following treatment for Group A, all 18 participants were re-evaluated (Time 2). Group B then began treatment, while no treatment was provided for Group A. Once Group B had completed their 15 weeks of treatment, they were re-evaluated (Time 3).
Follow-up testing for 16/18 participants who were still available occurred approximately two years later.

The basic treatment design of delaying treatment for one group was intended to help ensure that the treatment itself, and not some extraneous effect such as normal development, was responsible for any effects observed (Gruber, Lowery, Seung, & Deal, 2003). In addition, the two-year follow-up was intended to examine long-term maintenance of any gains observed.

Given the small sample size, a conservative approach was taken by using non-parametric statistics. An alpha level of .05 was used.

**RESULTS**

Performance at all four test times is shown in Table 2. At Time 1, Group A scored a mean of 3.3% correct of SATPAC phrases containing /s/ and /z/ ($SD = 10.0\%$) and 4.4% correct in spontaneous conversation ($SD = 13.3\%$). Corresponding values for Group B were 15.6% ($SD = 29.2\%$) and 13.6% ($SD = 20.8\%$). Analysis indicated that the groups did not differ significantly on either phrases or spontaneous conversation (Mann-Whitney $p = .43$ and .29 respectively) at the beginning of the study.

At Time 2, after Group A had undergone 15 weeks of therapy, accuracy by Group A improved to a mean of 97.8% in phrases ($SD = 4.4\%$) and 76.9% in spontaneous conversation ($SD = 30.8\%$). This represented a significant improvement from Time 1 on both measures (Mann-Whitney $p < .001$ and $p = .002$, respectively). Corresponding means for Group B, who had not yet received treatment, were 18.9% ($SD = 33.3\%$) for phrases and 10.7% ($SD = 14.6\%$) for spontaneous conversation and represented no significant change from Time 1 on either measure (Mann-Whitney $p = .76$ and $p < .001$ respectively). Thus, Group A had improved significantly, while Group B had not changed.

At Time 3, after Group B had undergone 15 weeks of therapy, Group B scores improved to a mean of 100% in phrases and 73.8% in spontaneous conversation ($SD = 23.2\%$). This represented a significant improvement from Time 2 on both measures (Mann-Whitney $p = .002$ and $p < .001$, respectively).

A comparison of Group A performance at Time 2 and Group B performance at Time 3 (i.e., at the end of each group’s treatment period) indicated no significant difference between the groups on either measure (Mann-Whitney $p > .99$ and $p = .76$, respectively). Thus, the two groups had improved to similar levels during their respective treatment periods.

At the two-year follow-up, analysis was based on the spontaneous conversational samples for 7/9 participants from Group A and all nine participants from Group B. Mean values were 59.1% ($SD = 41.0\%$) for Group A and 80.9% ($SD = 31.5\%$) for Group B. Both groups continued to perform
significantly better at the two-year follow-up compared to Time 1 (Mann-Whitney $p = .003$ in both cases). At follow-up, the two groups were also not significantly different from each other (Mann-Whitney $p = .76$).

**DISCUSSION**

The SATPAC approach appeared to be effective in treating dentalized and interdental errors on /s, z/. Both groups demonstrated significant improvement during their respective treatment periods. It would appear that the treatment was responsible for the change. Data from the two-year

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*Note.*—Cell entries are percent correct production for both targets combined.
follow-up suggested that by and large treatment effects had been maintained. The obtained outcomes appeared to be the consequence of the particular combination of elements in the SATPAC approach. When compared to the average time to remediate single sound errors of 17–20 hours in other studies (Taps, 2008), the current findings represent a significant reduction of direct therapy time (i.e., SATPAC would appear to be quite time-efficient). A period of 10 minutes of therapy for 15 weeks was sufficient to remediate /s/ and /z/ for most of the participants.

The incorporation of nonsense words is a key element of the SATPAC approach. Brief intensive treatment using nonsense words may be a potential solution for those individuals who persist with /s/ and /z/ misarticulations, because nonsense words may circumvent habitual speech patterns (Winitz, 1975). The current study was conducted in a school that was economically disadvantaged. Participants in the study demonstrated improvement following school speech therapy and this suggests that by itself, low SES need not limit success in therapy (Bernthal, et al., 2013).

Limitations and Future Directions

The most obvious limitation of the current study is that the focus was on a single pair of phonemes. Study of other speech sound targets is needed to see if this approach will work for more than just /s, z/. Another limitation is the fact that the person administering the program was also its developer. Having had extensive experience with the program means the current results may not be representative of results that might be obtained by a typical clinician without such experience. The fact that the SATPAC approach includes so many different elements only amplifies this limitation. It may take some time for clinicians to become fully familiar with all those elements.

Treatment fidelity measures were not carried out in the current study because the first author had been somewhat naive to research design and had not conducted video recordings of any of the treatment sessions. There was also no monitoring of the homework practice (we simply accepted the children’s word that they had done it). Until recently, treatment fidelity measures have not been routinely carried out, and therefore this is a shortcoming which is common to much of the intervention literature in speech sound disorders.

It is also not totally clear whether all of the included elements in the approach are actually necessary to ensure the kind of success observed in the current study. In particular, the current study utilized a non-traditional approach to teaching correct placement. It is not clear how crucial that particular technique was to the current findings. Further systematic study of the approach where various elements are left out or modified might help sort this out.
Due to time limitations in the study (150 minutes total), most of the Establishment Phase of the program was not used. The goal of the Establishment Phase is to have the participant correctly establish the appropriate phonetic context key word (e.g., /bitsik/) in seven different production pattern steps with 20 repetitions per step at 95% accuracy (initial syllable stress, final syllable stress, use in phrases, sentences, etc.). Because the participants in the study developed competence saying the phonetic context key word by initially practicing smaller units of the word (i.e., /its/) and then eventually the key word /bitsik/, it was the authors’ hypothesis that the Establishment Phase was redundant. The failure of some participants to fully master the targets in the current study may have been a consequence of leaving out much of this phase of the SATPAC program. It would be valuable to conduct future studies with and without the Establishment Phase to determine its affect on participant speech performance.

Although the inclusion of bilingual speakers suggests that this approach may be useful for this population, small numbers and the fact that three different other languages were included suggests that such a conclusion would be quite premature. Further study is indicated.

Finally, the SATPAC program allows for generation of a highly structured and systematic set of stimuli which includes provision for avoiding other speech sound errors. The question of whether most clinicians would be capable of or even have the time to create such individualized stimuli without the program needs to be examined.

REFERENCES


Accepted September 18, 2013.

APPENDIX

Basic Outline of the SATPAC Treatment Sequence

**Pre-Treatment: Correct Placement**

Use whatever procedure results in correct production of /s/ in the target nonsense word at a slow conversational rate (140 words per minute). For the current study, the non-traditional /i/-point procedure was used (see text for details).

**Phase 1: Establishment**

A single bisyllabic nonsense word containing the target is used here for all steps.

1. Bisyllabic nonsense word by itself slowly.
2. Bisyllabic nonsense word with target phoneme prolonged.
3. Bisyllabic nonsense word with equal stress on both syllables.
4. Bisyllabic nonsense word with stress on syllable containing the target phoneme.
5. Bisyllabic nonsense word with stress on syllable not containing the target phoneme.
6. Bisyllabic nonsense word in phrases and sentences.
7. Bisyllabic nonsense word in sentences with stress on various words in the sentences.
**Phase 2: Intratherapy Generalization**

A variety of different nonsense words containing the target sound in both pre- and postvocalic positions are used. This is intended to move the target sound systematically away from the facilitating context.

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</table>

**Phase 3: Transfer**

Real words are used with the target in various phonetic contexts. Practice also progresses through ever more complex linguistic levels (phrases, sentences, conversation)—this is very similar to the progression in traditional articulation therapy; the target is established at the word level.
Author Queries

AQ1: Provide address and e-mail address.
AQ2: What was the date of this meeting?
AQ3: City, state?
AQ4: Add date of this presentation.