

Stimulability and Treatment Success

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This article addresses 2 questions of importance to the treatment of speech sound disorders: (1) When selecting treatment targets, is it best to begin with the most or the least stimuable potential phoneme targets? (2) When treating unstimuable phonemes, which treatment procedures will result in the best outcome? A summary of the findings from 3 randomized controlled trials is provided. In these studies, outcomes were generally better when stimuable targets were treated; however, outcomes for unstimuable targets were improved by including phonemic perception training alongside phonetic placement procedures in the treatment program. The clinician must take final responsibility for judging the applicability of these research findings to each individual case. Clinical decisions should be made after discussing the known benefits and risks of any given treatment practice with the client and/or the client's family. **Key words:** *evidence based practice, phonological disorder, speech perception, speech sound disorder, speech therapy, stimulability*

STIMULABILITY reflects a child's ability to correctly imitate a given phoneme when provided with the instruction to "watch and listen" followed by models of the phoneme, usually in the context of nonsense syllables or simple real words (for an historical overview of the clinical application of stimulability-testing procedures, see Powell & Miccio, 1996). Stimulability testing is recommended as an essential part of an assessment, even when the "clock is running" and the clinician is forced to make departures from ideal assessment practices (e.g., Bleile, 2002; Miccio, 2002).

One reason for including stimulability testing in an assessment of a child's phonological skills is that the results may have clear prognostic indications. Improvements in articulatory accuracy for an unmastered phoneme are more likely to occur over a given time period when the child is stimuable, rather than unstimuable, for accurate production of the speech sound in question (e.g., Miccio, Elbert, & Forrest, 1999; Tyler, 1996). Furthermore, children who have generally higher levels of stimulability show better progress over time than children who have generally lower levels of stimulability (e.g., Sommers, Leiss, Delp, Gerber, Fundrella, Smith, Revucky, Ellis, & Haley, 1967). These findings apply regardless of whether children show typical or delayed speech development and regardless of whether they are receiving intervention.

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The author helped develop and has a financial interest in Speech Assessment and Interactive Learning Systems, a treatment procedure that was evaluated in several of the studies summarized in this article.

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There is a consensus that stimulability test results also have implications for treatment planning in general and for target selection in particular. There is considerable controversy about the clinical implications of stimulability or a lack thereof for the design of an effective phonology intervention, however (for an historical overview of this controversy, see Powell & Miccio, 1996). Basic research on stimulability presents a problem for clinical decision making because the apparent

implications of the basic research findings are contradictory: if stimuable phonemes improve even without treatment, the logical course of action might be to avoid these phonemes as treatment targets and focus intervention on the unstimuable phonemes; on the other hand, if unstimuable phonemes do not improve even when they are treated, an equally logical course of action might be to avoid them as treatment targets and focus intervention on the stimuable phonemes. Resolving the issue requires the clinician to review the relevant literature while applying the principles of evidence-based practice to identify the course of action that is likely to lead to the best clinical outcome for a given client. The purpose of this article is to examine the empirical evidence relating to treatment of unstimuable and stimuable phonemes.

THEORIES ABOUT THE NATURE OF STIMULABILITY

Traditionally, stimulability was viewed as evidence of the structural and functional integrity of the child's speech mechanism. A more recent theory posits that the ability to imitate a speech sound reflects underlying phonological knowledge about the phoneme (Powell & Miccio, 1996). Phonological knowledge includes an understanding of the linguistic features that form a given phoneme, the contrastive relationships between the phoneme and other phonemes, and the phonotactic environments in which a given phoneme may occur. Underlying phonological knowledge is, in turn, seen as the basis for generalization of articulatory accuracy both within and across phonemes and phoneme classes. This theoretical perspective is linked to the suggestion that unstimuable phonemes should be the focus of intervention because teaching these sounds provides an opportunity to introduce new phonological knowledge that will reorganize the child's phonological system and result in enhanced generalization of learning from treated to untreated phonemes.

Lof (1996) examined the correlates of stimulability in an effort to illuminate the relationship between stimulability and phonological knowledge. Thirty children's underlying phonological knowledge for each of several commonly misarticulated phonemes was determined by assessing phonemic perception using a procedure recommended by Locke (1980). Specifically, the child was asked to judge the correctness of target words produced by an adult, either correctly or with a simulated error (i.e., if the child has correct phonemic perception for the /l/ phoneme, [lif] should be perceived as a correct production of the word "leaf" but [wif] should be judged to be incorrect). Lof found that all possible combinations of phonemic perception performance and stimulability occurred. For example, the same child might perceive /k/ and be stimuable for this phoneme, perceive /r/ and not be stimuable for this phoneme, misperceive /l/ and be stimuable for this phoneme, and misperceive /s/ but not be stimuable for this phoneme. Rvachew, Rafaat, and Martin (1999) replicated this finding with two additional samples of children, using a similar test procedure except that recordings of authentic rather than simulated error productions were used for the phonemic perception task. These data, summarized in Table 1, demonstrate that underlying knowledge of a phonological contrast and stimulability are independent constructs.

Lof (1996) found that stimulability was positively associated with greater visibility of the target sound, older age of the child, higher socioeconomic status of the family, and greater overall speech-imitation abilities of the child as reported by the parent. Lof speculated that stimulability may also reflect child *focus* (Kwiatkowski & Shriberg, 1993), meaning the propensity of the child to attend to the relevant aspects of the model combined with the child's motivation to change his or her production accuracy.

These research findings suggest that stimulability and phonemic perception are independent abilities that are each required for phoneme acquisition as illustrated in Figure 1.

Table 1. Relationship between phonemic perception and stimulability across three studies and 53 children*

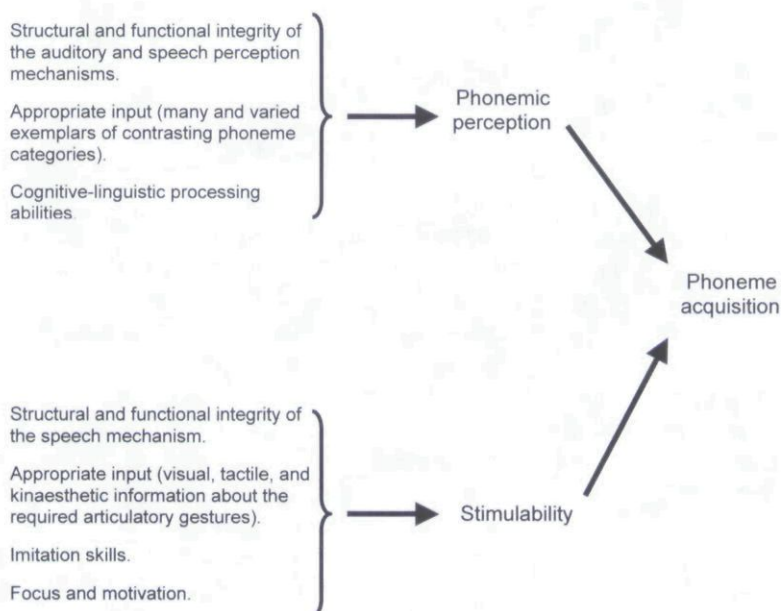
Study	Perceive and stimuable	Not perceive and not stimuable	Perceive but not stimuable	Not perceive but stimuable
Lof (1996)	6	10	9	5
Rvachew et al. (1999), Study 1	10	3	1	7
Rvachew et al. (1999), Study 2	10	2	6	8
Total	26	15	16	20

*The values represent numbers of phonemes corresponding to each combination of perceptual ability and stimulability. The totals sum to greater than the number of subjects because multiple phonemes were tested per subject. The total number of phonemes assessed, summed across the 53 children, was 77.

Stimulability reflects the structural and functional integrity of the speech mechanism, the child's access to visual, tactile, and kinaesthetic information about the required articulatory gestures, imitation skills, and child focus. Phonemic perception arises from the structural and functional integrity of the child's auditory and speech perception mechanisms, the child's access to appropriate speech input, and the cognitive-linguistic skills re-

quired for processing and learning from that input.

The framework illustrated in Figure 1 also reflects the finding that stimulability does not by itself lead directly and inevitably to phoneme acquisition, even when the child receives therapy for remediation of the speech sound errors (Miccio et al., 1999; Tyler, 1996). Rvachew et al. (1999) showed that improvements in speech sound accuracy for a given

**Figure 1.** An illustration of the proposed relationships among phonemic perception, stimulability, and phoneme acquisition.

phoneme were most likely to occur when the child demonstrated stimulability *and* phonemic perception prior to the onset of a 12-week phonology intervention (improvements were observed for 64% of phonemes that were perceived and stimutable and 0% of phonemes that were not perceived and not stimutable).

A theory of the process by which phonemic perception and stimulability might interact to produce phoneme acquisition is instantiated in a neural network model called *Directions in auditory space to Velocities in Articulator space* (DIVA; Guenther, 1995). A central feature of this model is that the goal of articulation is assumed to be the achievement of a particular acoustic-phonetic product (as opposed to a specific constellation of articulatory gestures). The learner uses auditory feedback to identify deviations from the desired acoustic-phonetic target space and then adapts the articulatory gestures to both achieve and maintain articulatory accuracy, even as the vocal tract is undergoing developmental changes in size and shape (Callan, Kent, Guenther, & Vorperian, 2000). For example, the /ʃ/ phoneme is characterized not by a specific peak frequency of noise energy, but rather by a range of frequencies that are low relative to those peak frequencies that characterize the /s/ phoneme. Feedback of the acoustic-phonetic product of speech movements allows the child to learn to produce the varying constellations of articulatory gestures that will result in this phoneme in different phonetic contexts (e.g., greater tongue retraction is required in the context of unrounded than rounded vowels).

Figure 1 also suggests some intervention procedures that may be effective. The emergence of phonemic perception and stimulability each require certain inputs to the child that are fully under the control of the clinician. Many empirical investigations have revealed the type of input that is required for the induction of categorical perception of phonemes (Guenther, Husain, Cohen, & Shinn-Cunningham, 1999; Maye, Werker, & Gerken, 2002; Rvachew, 1994). Specifically, the learner must hear a broadly varying distri-

bution of exemplars of contrasting phoneme categories. For example, when teaching the child to perceive the contrast between /s/ and /ʃ/, it is best to present a large number of exemplars of words containing /s/ and words containing /ʃ/, ideally produced by different talkers. Most of the words that the child hears should represent the prototypical exemplars of the two sound categories (i.e., lower frequency fricative noise for /ʃ/ and much higher frequency fricative noise of /s/). However, it is also important to present some exemplars of these phonemes that are less than ideal, even those approaching the category boundary between the two sounds.

The inputs required for achieving stimulability should provide information about the appropriate positioning of the articulators and help the child focus attention on tactile and kinesthetic feedback associated with the production of the appropriate articulatory gestures. Modelling, shaping, and phonetic placement techniques are suggested in Secord (1981) and have been shown to be useful for remediating speech sound errors (Powell, Elbert, Miccio, Strike-Roussos, & Brasseur, 1998).

EVALUATING THE EVIDENCE

Although many treatment efficacy studies that are relevant to the topic of stimulability have been published, most of these have employed experimental (e.g., multiple baseline) or nonexperimental (e.g., multiple probe) single-subject designs and thus are not particularly well suited to the two research questions considered here (Gierut, Elbert, & Dinnsen, 1987; Gierut, Morrisette, Hughes, & Rowlands, 2001; Powell, Elbert, & Dinnsen, 1991; Tyler & Figurski, 1994). A full review and critique of all the relevant treatment efficacy studies is beyond the scope of this article. However, a few studies involving a randomized controlled design will be discussed. A randomized controlled trial is essential for studying this topic because it is the only design that can help differentiate maturation from generalization and treatment effects (for

further discussion of research design issues, see Rvachew & Nowak, 2001).

STIMULABILITY AND TARGET SELECTION STRATEGY

Rvachew and Nowak (2001) investigated the relative effectiveness of two distinct target selection strategies on treatment outcomes, using a randomized controlled design. Forty-eight 4-year-old children with moderate or severe speech sound disorders received a pre-treatment assessment (A1), a 6-week block of treatment targeting two consonant phonemes (block 1), a second assessment (A2), another 6-week block of treatment targeting two additional consonant phonemes (block 2), and a posttreatment assessment (A3). All assessments were conducted by a speech-language pathologist who was blind to the child's group assignment and treatment targets. The treatment approach during each block was traditional, with phonetic placement, shaping, and modelling techniques used to establish stimulability at the syllable level. Once stimulability in syllables was achieved, the child was provided with opportunities for articulation practice in imitated words, spontaneous words, imitated patterned sentences, spontaneous patterned sentences, imitated sentences, and spontaneous sentences. All children began the treatment program at the stimulation phase and progressed from one treatment step to the next upon achieving 80% correct responding.

The phonemes that were targeted during the two treatment blocks depended on whether the child was assigned at random to receive treatment for the *most stimutable, early developing* sounds (ME group) or the *least stimutable, late developing* sounds (LL group). At each of the three assessments, the child was asked to imitate all items from the Productive Phonological Knowledge Profile (Gierut et al., 1987), which provides 15 opportunities to produce most of the English consonants. The child's responses were used to rank the child's unmastered phonemes according to type of Productive Phonological

Knowledge. Gierut et al. described six types of productive phonological knowledge that reflect the consistency with which the child articulates a given phoneme across word positions. Potential treatment targets were those phonemes that were at type 4 (mastered in at least one but not all three word positions), type 5 (inconsistently correct but not mastered in any word position), or type 6 (never correct). Rvachew and Nowak considered type 6 phonemes in their study to be unstimulable because the child failed to produce the phoneme correctly even after 15 opportunities to imitate it in simple words. These potential treatment targets were further ranked within each type of Productive Phonological Knowledge according to the 90th percentile age of acquisition, according to Smit, Hand, Freilinger, Bernthal, and Bird (1990). In each treatment block, children assigned to the ME group received treatment for the two sounds that were most stimutable and earliest developing, with the proviso that the two sounds not share the same manner class (e.g., /k/ and /f/ would be selected as treatment targets rather than /k/ and /g/). Children assigned to the LL group received treatment for the two sounds that were least stimutable and latest developing, again with the constraint that the two sounds not share the same manner class (e.g., /r/ and /s/ would be selected as treatment targets rather than /s/ and /ʃ/). The criteria for choosing targets for children in the LL condition effectively ensured that this group would receive treatment for unstimulable sounds, at least during the first treatment block. The most frequently targeted sounds during the first treatment block for the ME group were /k/ and /f/. The most frequently targeted consonants during the first treatment block for the LL group were /s/ and /r/.

Figure 2 shows mean group response accuracy for three sets of consonants from the Productive Phonological Knowledge Profile for the three assessments, with the ME group's performance shown in the left panel (2a) and the LL group's performance shown in the right panel (2b). The three sets of consonants illustrated in Figure 2a are the most stimutable

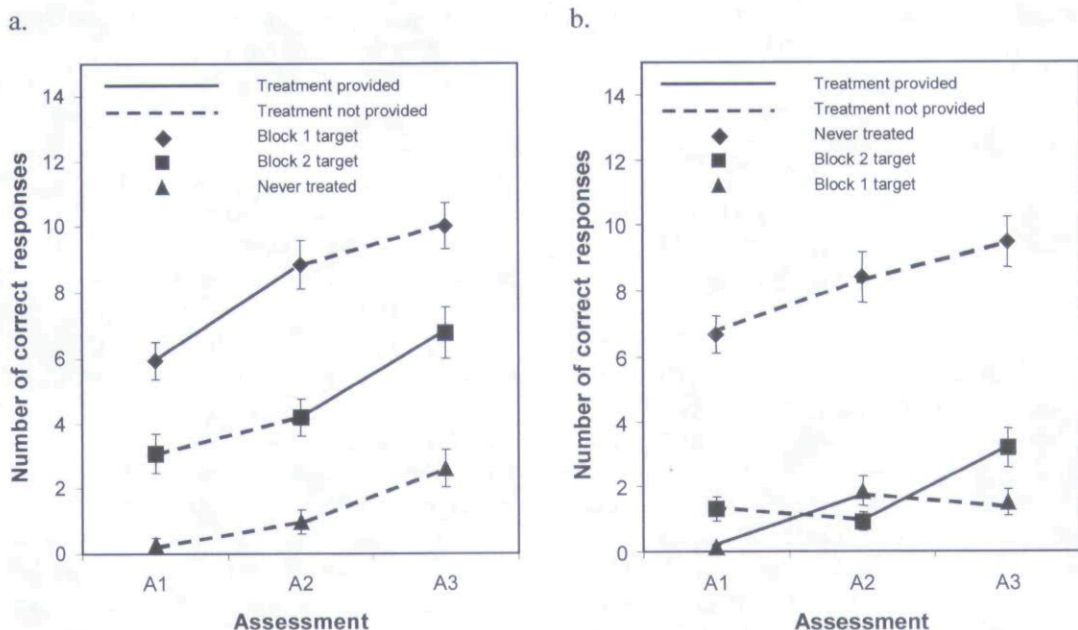


Figure 2. Mean number of correct responses for certain consonants on the Productive Phonological Knowledge Profile, administered at three assessment points: prior to treatment (A1), after the first treatment block (A2), and after the second treatment block (A3). The panel on the left (a) shows the results for children in the ME group, and the panel on the right (b) shows the results for the children in the LL group. (Based on data from Rvachew & Nowak, 2001).

phonemes (treated in the first block), the second most stimutable phonemes (treated in the second block), and the least stimutable phonemes (never treated in the ME group). The three sets of consonants illustrated in Figure 2b are the least stimutable phonemes (treated in the first block), the second least stimutable phonemes (treated in the second block), and the most stimutable phonemes (never treated in the LL group).

Expressing the change in scores from one assessment to the next in the form of mean residualized gain scores allows for a number of different comparisons of relative rate of change, after taking into account the child's pretreatment level of productive accuracy for these phonemes (specifically, a residualized gain score is the difference between the child's actual posttreatment probe score and the score that would be predicted from the child's pretreatment probe score, as determined by a regression equation derived from

the pretreatment and posttreatment probe scores for all 48 children).

First, the rate of change during blocks when the phonemes were treated was compared with the rate of change observed during blocks when the phonemes were not treated. These analyses were conducted separately within each group and confirmed the differences in rate of change that are readily observable in Figure 2. For the ME group, the rate of change for the most stimutable phonemes was higher during the block when these phonemes were treated, than during the block when these phonemes were not treated; 0.44 versus 0.05; $t(95) = 2.60$, $p = .011$; see solid lines versus dashed lines for blocks 1 and 2 targets in Figure 2a. For the LL group, the rate of change for the least stimutable phonemes was higher during the block when these phonemes were treated, than during the block when these phonemes were not treated; 0.08 versus -0.56 ; $t(95) = 4.58$,

$p = .000$; see solid lines versus dashed lines for blocks 1 and 2 targets in Figure 2b. In other words, gains were greater for block 1 targets during block 1 than during block 2, whereas gains were greater for block 2 targets during block 2 than during block 1. This was true for both groups.

The second analysis considered rate of change for treated phonemes across the ME and LL groups. The rate of change in production accuracy from A1 to A3 for treated *stimulable* phonemes was greater than the rate of change for treated *unstimulable* phonemes; 0.25 versus -0.51 ; $t(94) = 3.78$, $p = .000$; highest line in Figure 2a versus lowest line in Figure 2b.

The third analysis considered the relative rate of change for stimulable phonemes across the ME and LL groups. From A1 to A3, the rate of change shown by the ME group for *treated* stimulable phonemes was not significantly greater than the rate of change shown by the LL group for *untreated* stimulable phonemes; 0.25 versus 0.21; $t(94) = 0.22$, $p = .829$; highest line in Figure 2a versus highest line in Figure 2b.

The final analysis considered the rate of change for unstimulable phonemes across the ME and the LL groups. From A1 to A3, the rate of change shown by the ME group for *untreated* unstimulable phonemes was actually significantly *greater* than the rate of change shown by the LL group for *treated* unstimulable phonemes; 0.05 versus -0.51 ; $t(94) = 2.97$, $p = .000$; lowest line in Figure 2a versus lowest line on Figure 2b. Overall, treatment progress was very poor for unstimulable phonemes but treating the stimulable phonemes first appeared to facilitate improvements for unstimulable phonemes in the ME group.

Other more global measures of change in this study, including Percentage of Consonants Correct, did not reveal any significant differences in outcomes between the two groups of participants. Therefore, it is not surprising that the most appropriate interpretation of these findings is a matter of continuing debate (Morrisette & Gierut, 2003;

Rvachew & Nowak, 2003). However, there is no doubt that, in this study, which involved a traditional treatment approach, children were most likely to master the targeted consonant when it was stimulable (further studies are required to determine whether this same outcome would be achieved in the context of a phonological intervention involving minimal pairs procedures).

Parents and clinicians were most satisfied with the outcome of the ME target selection strategy. Targeting stimulable sounds first did not prevent the children from making spontaneous improvements toward correct production of other more difficult phonemes; in fact, the ME group showed greater progress for *untreated* unstimulable phonemes than did the LL group for *treated* unstimulable phonemes. Absolutely no improvement was observed for 45% of treated unstimulable targets. For these reasons, Rvachew and Nowak (2001) concluded that the most prudent strategy for most children is to target stimulable phonemes first. On the other hand, 10% of children in the LL group actually mastered a treated unstimulable target sound. Stimulability should never be the only variable under consideration when selecting the most appropriate phonemes to remediate.

EFFECTIVE TREATMENT OF UNSTIMULABLE PHONEMES

There are many cases when it is necessary to target a phoneme for which the child is unstimulable. The phoneme that has the most impact on intelligibility may be unstimulable for example. If an entire class of phonemes is missing from the child's repertoire, you will be forced to introduce one or more members of this class even if the child is unstimulable for all of the relevant phonemes. Therefore, it is important to identify treatment procedures that will result in better outcomes for unstimulable phonemes than those observed by Rvachew et al. (1999) and by Rvachew and Nowak (2001). To follow is a summary of two studies showing that phonemic perception

intervention can facilitate the acquisition of stimulability and eventual mastery of target sounds.

The framework shown in Figure 1 suggests that acquisition of a given phoneme requires accurate phonemic perception of the targeted phoneme contrast and stimulability for the target phone. Rvachew (1994) conducted a randomized control trial to test this hypothesis. In this study, six once-weekly treatment sessions were provided to 27 preschoolers with speech sound disorders, all of whom were completely unstimulable for /ʃ/. Each treatment session for all children consisted of 10 min of phonemic perception training implemented in a computer-game format, followed by 20 min of articulation therapy directed at the /ʃ/ phoneme. The treatment approach during the articulation therapy part of the sessions was traditional, with phonetic placement, shaping and modelling techniques used to establish stimulability at the isolation and syllable levels. If stimulability was achieved, the treatment program progressed in steps from imitated words through progressively longer units of speech. All children began the treatment program at the stimulation phase and progressed from one treatment step to the next upon achieving 90% correct responding. The phonemic perception training procedure was also the same for all children: the child was asked to listen to recorded words and identify those words that were good exemplars of a particular target. The stimuli that the children listened to depended on the child's group assignment, however. The experimental group listened to a variety of exemplars of the word "shoe" recorded from adults and children, with half the words being correct exemplars and the other half of the words representing common misarticulations of this word (e.g., [tu], [su], [θu]). When the child accurately identified a word as being "shoe" or "not shoe," interesting cartoon characters appeared on the computer screen to reinforce the children for correct responding.

This study involved two control groups. The first control group listened to repeated presentations of a single prototypical record-

ing of the word "shoe" and a single prototypical recording of the word "moo" and responded as described above for the experimental group. This control group was included to confirm the importance of presenting children with a variety of exemplars of the target phoneme, as opposed to presenting only perfect or prototypical exemplars of the target sound.

The second control group listened to the words "cat" and "Pete" produced correctly by a single adult talker. These children were expected to identify correct versions of the word "cat." The clinician who conducted the articulation therapy was blind to the child's group assignment. This control condition was not expected to impact the children's speech perception skills. Rather, it provided a control for other aspects of the phonemic perception training procedure (e.g., extra therapy time and individual attention, the opportunity to play a fun computer game).

Outcome assessments were also conducted by a blind observer. On average, the children in the experimental group achieved stimulability and then learned to produce the /ʃ/ phoneme at the level of spontaneous words. In contrast, only one child in the second control group achieved stimulability at the isolated sound level. The remaining children in this group experienced no gain even after 6 weeks of therapy. The performance of the group that heard "shoe" and "moo" was intermediate between the experimental group and the second control group. Percent correct responding on a spontaneous object naming probe also confirmed that the phonemic perception training procedure facilitated the children's acquisition of this difficult phoneme. Furthermore, presenting the children with a variety of good quality and lesser quality exemplars of the target word produced by multiple child and adult talkers was particularly effective.

Subsequently, a commercial version of the phonemic perception training program that was administered to the experimental group in Rvachew (1994) was developed and expanded to cover additional phonemes in the

word initial and word final positions (Speech Assessment and Interactive Learning System [SAILS]; AVAAZ Innovations, Inc., 1994). A recent randomized controlled trial demonstrated that this program enhanced sound production learning by children receiving phonological interventions (Rvachew, Nowak, & Cloutier, 2004). In this study, 34 pre-school-age children with moderate or severe speech sound disorders were randomly assigned to an experimental treatment program or a control program that was offered as a supplement to their regular speech therapy sessions. Each child received 16 once-weekly speech therapy sessions in which the child's clinician selected treatment targets and provided the interventions that she felt were appropriate. After each of these sessions, the child received an additional 10-min intervention that was administered by a student research assistant. The children assigned to the experimental condition received the SAILS program targeting eight consonants. The children assigned to the control condition listened to computerized books. Again, treating clinicians were blind to the child's group assignment as was the speech-language pathologist who conducted the outcome assessments. The posttreatment assessment revealed that the experimental group demonstrated significantly greater articulation accuracy in single-word naming and in conversation than did the control group. Furthermore, a follow-up assessment 1 year later, when the children were approaching the end of kindergarten, revealed that 50% of experimental group children had achieved age-appropriate articulation skills whereas only 19% of control group children had achieved articulation skills that would be considered typical.

One of the outcome measures was Percentage of Consonants Correct in conversation for specific phonemes that were not mastered by the children prior to treatment, calculated before and after treatment. The children who received the SAILS program made greater improvements in articulation accuracy for these phonemes than children who were assigned to the control condition. This benefit to the

SAILS group was observed for 11 of the 13 difficult sounds that were monitored in this study (see Figure 1 of Rvachew et al., 2004).

Although the study by Rvachew et al. (2004) was not directly concerned with stimulability, details of the pretreatment and posttreatment conversation samples suggested that this combination of articulation therapy and phonemic perception training enhanced outcomes for unstimulable phonemes. Figure 3 shows the change in percent correct articulation of certain consonants from the pretreatment to the posttreatment assessment, as described above. However, in this case, the changes in articulation accuracy are shown as a function of pretreatment inventory status. In other words, the figure shows change in articulation accuracy separately for phonemes that were present in the child's inventory prior to treatment (and thus clearly stimulable) and for phonemes that were never produced in the child's inventory prior to treatment (and thus not likely to have been stimulable). Figure 3a shows that children in the SAILS group made a 27% improvement in /ʃ/ accuracy regardless of whether this phoneme was present in the child's pretreatment conversational sample. Children in the control group who were stimulable for /ʃ/ made more than twice the gain in production accuracy for this phoneme than did control group children who never produced this sound prior to treatment. The results for /θ/ and /t/ indicated that change from no correct productions to at least some correct productions occurred only for children who received the SAILS intervention.

CONCLUSIONS

Two questions were asked about the treatment of stimulable and unstimulable phoneme targets: (1) When selecting treatment targets, is it best to begin with the most or the least stimulable potential phoneme targets? (2) When treating unstimulable phonemes, which treatment procedures are associated with the highest probability of

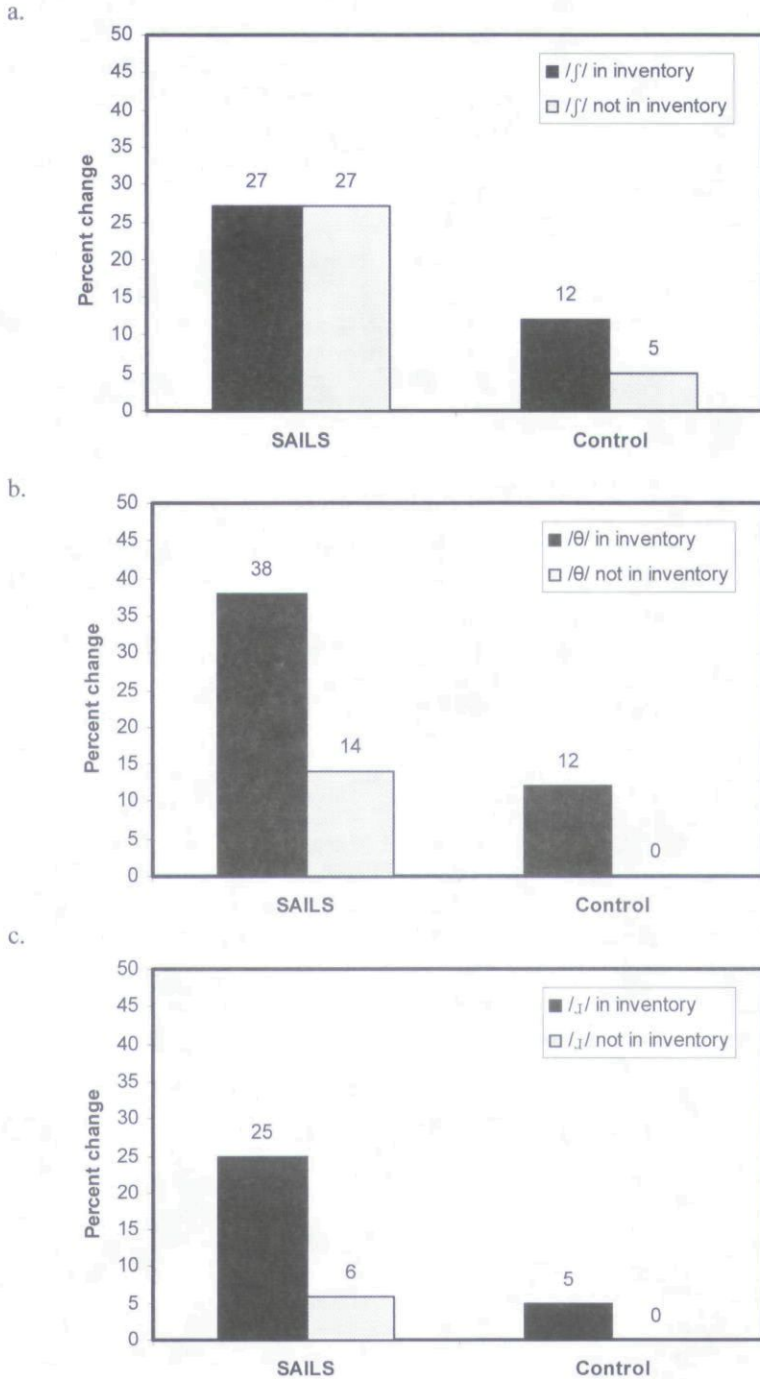


Figure 3. Pretreatment to posttreatment improvements in percent correct production of certain consonants for children who received the SAILS phonemic perception training program versus children who were assigned to the control group, as a function of pretreatment inventory status. (Based on data from Rvachew et al., 2004).

achieving accurate articulation of the new phoneme? With regard to the first question, a randomized controlled trial led to the conclusion that treatment of the most stimuable potential targets is likely to result in a greater rate of change for the treated phoneme than is treatment of the least stimuable potential targets. The results of this study also suggested that a target selection strategy that begins with the most stimuable and earliest developing phonemes will facilitate the spontaneous emergence of unstimuable phonemes. However, these findings reflect only a single study. Greater confidence in these conclusions could come from replications and extensions of this study in additional randomized controlled trials. Studies that examine other combinations of target selection criteria would be valuable. It is possible that the most effective targets, in terms of promoting system wide change, might be those phonemes that are stimuable but rarely produced correctly (in other words, phonemes representing Type 5 Productive Phonological Knowledge). Other possible ideal targets might be unstimuable but early developing phonemes or stimuable late developing phonemes. These hypotheses have not yet been investigated experimentally.

With regard to the second question, a number of studies have shown that a combination of phonemic perception and stimulability training enhances children's response to treatment (Jamieson & Rvachew, 1992; Rvachew, 1989, 1994; Rvachew et al., 1999, 2004). This enhancement of sound production learning is at least as dramatic for unstimuable phonemes as it is for stimuable phonemes. The DIVA model (Callan et al., 2000) suggests that this enhancement occurs because the SAILS phonemic perception training procedure provides the child with a stable acoustic-phonetic target for the phoneme being learned. This underlying acoustic-phonetic target allows the child to discover the mapping between the phoneme, the appropriate articulatory gestures, and the acoustic-phonetic outcome of those articulatory gestures.

This specific hypothesis about the mechanism by which the SAILS program enhances sound production learning has not been experimentally confirmed, however. Other explanations are possible. The treatment effect may be due to a more generalized process whereby the child learns to attend more carefully to speech input. Alternatively, the primary lesson that the child learns may be to make judgments about the accuracy of his or her own speech. Treatment approaches that require the child to self-monitor may be more effective than traditional clinician-monitoring procedures, regardless of whether the SAILS program is a component of the therapy. Furthermore, these studies of the efficacy of the SAILS program involved either a traditional behaviorist approach or a cycles phonological process approach to treatment (e.g., Hodson & Paden, 1983). The efficacy of the SAILS phonemic perception training program has not been evaluated in combination with a more linguistic approach involving minimal pairs procedures (e.g., Dean & Howell, 1986). Neither has the SAILS treatment program been evaluated in relation to the multiple phoneme program designed by Miccio to facilitate acquisition of stimulability (Miccio, 2005; Miccio & Elbert, 1996). Further studies regarding the efficacy of phonemic perception training to facilitate the acquisition of unstimuable phonemes are required.

It may be frustrating to clinicians that researchers always conclude that "more research is required." This inevitable conclusion does not mean that the available research cannot support clinical decision making. Randomized controlled trials do provide good information about the likely outcome of a given treatment practice for a given population of clients. The speech-language pathologist must make a judgment about the extent to which the research findings apply to a specific child in a specific clinical context. The clinician should also engage the child and the family in a discussion about the potential benefits and risks associated with the application of a given clinical practice. The research reviewed here suggests that there is

a very strong risk of achieving no gain after six or more weeks of therapy when unstimulable targets are treated using a behaviorist approach. However, there may be many situa-

tions in which the potential benefits outweigh the known risk. The choice of treatment approach for a given child is ultimately up to the clinician.

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