SPEECH ASSESSMENT AND INTERACTIVE LEARNING SYSTEM

Welcome to the SAILS 'Backgrounder'

This information package was developed by Dr. Susan Rvachew to help speech-language pathologists decide when and how to use SAILS, in accordance with the principles of evidence based practice. The contents are as follows:

About the Author

How to install and run SAILS on Windows 7 / 64 bit PCs

Scientific Background

About the Author

Dr. Susan Rvachew obtained a B.Sc. in Speech-Language Pathology from the University of Alberta in 1980, a M.Sc. in Psychology from the University of Calgary in 1987, and a Ph.D. in Psychology from the University of Calgary in 1995. She practiced speech-language pathology in pediatric settings for 20 years. Currently she is a Professor in the School of Communication Sciences and Disorders at McGill University where she teaches Phonological Disorders at the graduate level and investigates speech development, speech disorders, and speech interventions. She has published over 40 peer reviewed papers and book chapters on these topics.
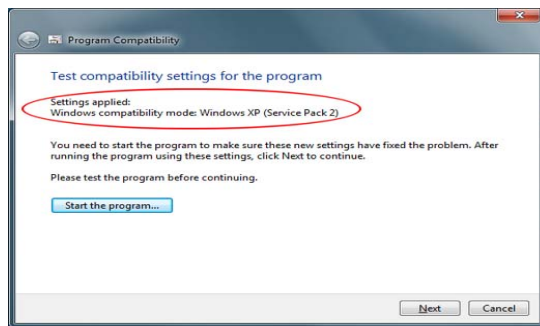
SPEECH ASSESSMENT AND INTERACTIVE LEARNING SYSTEM

How to install and run
SAILS
on Windows 7 / 64 bit PCs

There are no guarantees that this will work for everyone on every PC but we have had good success with this method. IF this does not work AND IF you have one of the Professional or Ultimate versions of Windows 7, THEN I suggest you investigate "Windows XP Mode" for Windows 7, available from Microsoft.

The SAILS software is delivered as a zip file. Double-clicking on the zip file in Win7 will open the zip file to reveal a folder called "Sails." So,

1. Double-click the zip file
2. Drag the Sails folder from the zip file window to a location on your hard drive. Sails will run from the "Program Files" directory but I suggest you avoid locations having very long file names
3. You can close the zip file window now
4. Open the Sails folder that you created in step 2
5. Locate sails.exe and click ONCE on it to select it.
6. (at this point you could double-click sails.exe to try to run the program and see if it works on your machine. If it does, you can drag sails.exe with the RIGHT mouse button to the desktop and choose "create shortcut" and you are done)
7. With sails.exe selected via a single click, now click on it again with the RIGHT mouse button. A menu will appear.
8. Click on "Troubleshoot Compatibility." If your menu does not have this selection, this is usually because sails.exe was not selected prior to the right-click.
9. Click "Try Recommended Settings."
10. After a short time you should get a window asking you to test the program:
11. Click "Start the program..."
12. Click YES on the usual Windows "do you really want to...." question
13. Sails should launch. Enter something in the two fields and test the program.
14. Exit Sails and return to the "Program Compatibility" window which will still be open.
15. Click Next.
16. In the next window, click the option to save the settings.

17. Windows will labor for a while before giving the the opportunity to close the troubleshooter.
18. You may now right click and drag sails.exe to your desktop or some preferred location and choose "create shortcut." This shortcut will now launch Sails with the appropriate settings to run on your machine.

During your Sails sessions, the program creates reports. The two buttons that should display these reports will not work but in fact the reports will be created in the Sails directory and can be viewed in Excel.

SPEECH ASSESSMENT AND INTERACTIVE LEARNING SYSTEM

I. Introduction to SAILS-2

I. Introduction to SAILS-2
1. What is SAILS?

SAILS is a computer based tool that can be used to assess or improve children's speech perception skills. It is intended to be used as part of a comprehensive intervention for children with speech sound disorders. SAILS targets commonly misarticulated consonant phonemes in the onset and coda position of words. The program is based on recordings of naturally produced words. These words were recorded from adult talkers with accurate speech, child talkers with accurate speech, and child talkers with a speech sound disorder. The child's task is to listen to each word and indicate whether it is an exemplar of the target word or not an exemplar of the target word. The child responds by pointing to a picture of the target word or to an 'X'. Visual feedback is provided after the child's response.

2. What's new in SAILS-2?

Speech items. The foundation of the program continues to be the natural recordings of words. The speech items targeting the original eight phonemes in word initial position remain the same ([k, f, l, ʃ, tʃ, θ, s, ɹ]). Additional speech items have been added to target these phonemes in word final position have been created and will be added in a future upgrade.

Task. SAILS-2 retains the original word identification task, in which the child indicates whether a spoken word is an exemplar of the target or not.

Graphics. The graphical stimuli used as response alternatives or feedback pictures have been changed in order to upgrade the format for modern computers.

Game play. Game play proceeds in the same manner as for the original game. An improved system of keeping track of child performance has been added to the new version however.

Software platform. The new software platform is *Authorware*.

3. Copyright

The original SAILS concept and the speech items were developed by Susan Rvachew with funding from the M.S.I. Foundation. The new software platform and graphics were developed by the Software Support Group of the Canadian Language and Literacy Research Network with Susan Rvachew acting as a consultant and Aaron Finkenzeller managing the project. All audio stimuli were provided by Susan Rvachew. The copyright to the current version is jointly held by Susan Rvachew and McGill University.

II. Introduction to Evidence Based Practice
    1. What is evidence based practice?
    2. Role of theory in evidence based practice
    3. Role of evidence in evidence based practice
    4. Role of the clinician in evidence based practice
    5. Role of the patient in evidence based practice

II. Introduction to Evidence Based Practice

1. What is evidence based practice?

Evidence based practice involves the integration of clinical expertise, the patient's values and preferences, and the best research evidence to make decisions about the care of individual patients.[1]

2. Role of theory in evidence based practice

There are a number of competing theories of speech development, each with different implications for intervention [2]. Any valid intervention will be based on a coherent and empirically supported theory. This is not to say that all aspects of the theory are proven or correct. However, there should be a theory that explains why the intervention might be effective that is backed by a body of supportive evidence.

3. Role of evidence in evidence based practice

In addition to basic research that supports the theoretical underpinnings of the research, confidence in the validity of the intervention is greatest when there is a solid record of good quality studies that support the efficacy of the intervention. For the purpose of demonstrating that an intervention is more effective than no treatment or an alternative treatment approach, a randomized control design is the best level of evidence. This design ensures that the improvements observed are due to the intervention and not due to other factors. Systematic reviews and meta-analyses are particularly helpful because the authors have evaluated the quality of the evidence and assessed the degree to which multiple studies converge on a given conclusion.

4. Role of the clinician in evidence based practice

It is up to the SLP to decide if an intervention is likely to be helpful for a particular patient. If your client is similar to the children who received the intervention in the context of the efficacy studies, the intervention will probably be helpful, provided that you can administer the intervention in a manner similar to that used in those studies.

5. Role of the family in evidence based practice

Ultimately, the SLP must decide which intervention or interventions are most appropriate for use with a given child. However, the parents' preferences must be taken into account. If the parents or child are unhappy with computer-based listening drills, then alternative methods to improve the child's perceptual phonological knowledge may be more appropriate.

III. Theoretical Underpinnings of the SAILS Approach

1. Multiple representation approach to phonological development

The development of speech accuracy involves the gradual accretion of knowledge in the perceptual, articulatory, and phonological domains as well as the progressive integration of knowledge among these domains [3]. Essentially, the child has to develop an understanding of what a word sounds like and how it is produced, as well as an understanding of the discrete phonological units that make up the word. In the past it was believed that phonological representations were innately determined but more recently it has been recognized that these representations emerge from the child's experience with spoken language.

The development of perceptual knowledge of words begins earliest, before the child is able to produce meaningful speech, but continues through late childhood. Even before the child understands the meaning of words, the infant notices regularities in the acoustic properties of speech inputs [4]. Consequently the infant develops acoustic-phonetic representations for sound categories that allow him or her to ignore acoustic variation that is not meaningful and attend selectively to acoustic variation that is meaningful. For example, the spectral energy peak in the [s] sound will vary from talker to talker (and indeed, from word to word), but in general it will be placed at a higher frequency for [s] than for [ʃ]. The development of robust acoustic-phonetic representations requires that the child receive plenty of speech input with lots of variation and that the child's auditory system be able to process and store that information efficiently.

Similarly the child must learn to produce the [s] and [ʃ] sounds accurately in varied phonetic contexts. The development of precise motor control requires that the child practice achieving a target, in multiple contexts, with feedback and knowledge of results [5, 6]. The foundation for the development of speech motor control is laid when the infant repeats syllables during the reduplicated babbling phase. The child is able to determine if the target was achieved by comparing the auditory feedback of the spoken output to the intended target. Sensory-motor feedback from the articulators allows the child to discover the mapping between intended targets and the articulatory movements required to achieve those targets. Notice that the child's perceptual knowledge of the speech target is a critical component of this process. Therefore deficits in speech motor control may implicate the integrity of the articulatory system itself but may also reflect imprecise perceptual representations for speech targets.

Words, in their acoustic and articulatory forms, cannot be segmented into discrete phonological units. The phoneme cannot be abstracted from a single word. However, abstract representations that are segmented at the phonemic level can emerge gradually as the child notices similarities and differences among words in the lexicon. Rapid growth in the size of the lexicon forces the child to reorganize mental representations in order to facilitate efficient access to lexical items during language comprehension and production [7, 8].

2. Speech Perception Skills of Children with Speech Sound Disorders

Many studies have shown that a large proportion of children with speech sound disorders have difficulty with speech perception in comparison to children of the same age who do not have speech sound disorders. The speech perception difficulties may not be obvious to parents and SLPs or other people who are talking with the child. However, these difficulties with speech perception have been found in studies using a large variety of assessment techniques and speech stimuli. Speech perception deficits have been observed when the children listened to live-voice or recorded natural speech [9-11], digitally altered natural speech [12, 13], and synthesized speech [14-16]. Children with speech sound disorders have demonstrated difficulties with both discrimination and identification tasks [10, 15]. They find it difficult to accurately perceive their own speech as well as speech produced by other talkers [11, 13]. What is the nature of the speech perception deficit as revealed by these studies?

- The children can usually perceive carefully enunciated speech when presented live-voice in ideal listening conditions.

- Speech perception performance is often impaired even with small degradations in the quality of the speech input or the listening conditions.

- The children's speech perception errors reflect their articulation errors. Therefore, if the child substitutes [w] for /ɹ/, they are likely to have difficulty discriminating [w] and [ɹ], but are not especially likely to have difficulty discriminating [l] and [ɹ].

- The children can usually identify correctly produced speech but have difficulty identifying misarticulated speech. For example, the child may know that [ɹɑk] refers to a stone and that [wɑk] is a form of locomotion. The same child might believe that [ɹʷɑk] is an acceptable variant of the word [ɹɑk] however.

- The children often attend to acoustic cues that are not reliable indicators of phoneme category. For example they may differentiate [θ] and [s] on the basis of the duration of the fricatives rather than the spectral characteristics of the fricatives.

- The children's speech perception difficulties may be associated with phonemic errors or with phonetic errors. For example one child may hear that [s] and [ʃ] are not acoustically the same but believe that [s] and [ʃ] are variants of a single phoneme class. Another child may understand that [s] and [ʃ] form different phoneme classes, but accept dentalized variants of these sounds as being equivalent to the undistorted exemplars.

- Overall, these studies indicate that children with speech sound disorders have non-adult-like perceptual phonological knowledge. Their perceptual categories for phonemes are too broad, encompassing both correct and incorrect productions of a given phoneme.

3. Relationship between speech perception and speech production abilities

Many studies have shown that speech perception ability is correlated with articulatory accuracy, with children who have better speech perception skills producing fewer speech sound errors [12, 15-17], and adults with poorer speech perception skills producing less distinct speech [18-20]. These findings do not prove that speech production errors are caused by speech perception deficits and some theories propose that speech perception ability arises from articulatory practice [21-23]. However, compelling evidence indicates that speech perception problems lead to speech production errors in young children [24].

The foundations of language-specific speech perception skills are laid very early in life, before the child begins to produce speech-like babble or meaningful speech. By 6 months of age, the infant is sensitive to the voice-onset-time contrasts and vowel categories that are specific to the maternal language [25]. Furthermore, speech perception abilities in infancy are correlated with receptive and expressive vocabulary size during the second year of life [26].

There is direct evidence that speech perception abilities contribute to growth in speech production accuracy during the preschool period [27]. In this longitudinal study, the speech perception and speech production abilities of children with a speech sound disorder were assessed when the children were 4-to-5 years old and again one year later. Hierarchical multiple regression analyses were conducted to assess the relationship between predictors at the earlier assessment and change in skill levels for the outcome variables over the next year. These analyses showed that speech perception at the earlier age predicted improvements in articulation accuracy over time. Articulation skills at the earlier age did not predict improvements in speech perception skills over time however.

Intervention studies show that speech perception training can lead to improvements in articulation accuracy, even when no direct speech therapy is provided. In one study [28], five single subject experiments were conducted. Each child was a preschooler who misarticulated fricative phonemes. During the experiment the child was asked to imitate sentences containing fricative sounds repeated over a period lasting approximately 90 minutes. Correct and incorrect articulations of target fricatives were counted but the child received no feedback about the correctness of his articulation. At a randomly selected point in the 90 minute period, speech perception training was introduced. Following this point, a brief interval of speech perception training was provided prior to each block of 10 sentence repetition trials. The child was presented with recordings of synthetically produced words that started with a fricative sound. The child was asked to identify the word by pointing to the appropriate picture (e.g., 'seat' or 'sheet', depending upon the word that was heard) and was given stickers to reward correct responses. The outcome varied with the child's pretreatment speech perception abilities and the success of the intervention. Three children began the experiment with poor speech perception skills but showed significant gains in speech perception abilities when the speech perception training was introduced. These children also showed spontaneous gains in speech production accuracy after the time at which the speech perception training activities were initiated. One child had good speech perception abilities for the target phoneme prior to the experiment. No gains in speech production accuracy were observed during the experiment. Another child had severe speech perception difficulties and did not learn the speech perception task. This child did not show a gain in speech production accuracy either.

4. Potential causes of speech perception difficulties

Recall that an extremely important factor in language development is the sheer amount of speech input that the infant and young child receives [29-31]. The way in which the speech input is provided makes a difference too. An 'infant-directed' speaking style helps the child to focus on the speech input and exaggerates the distinctions between contrasting speech sounds [32]. In older children, the nature of the social interactions between adult and child also plays a role in helping the child to learn from language input [33, 34]. Children who have speech and language deficits may not receive enough input, may not be able to hear the input, may not attend to the input, or may not be able to process the input in the normal way. These possibilities will be discussed in turn.

Children who are raised in poverty typically receive less speech input from their parents and show delays in speech perception, phonological awareness, and language development relative to children who receive adequate input [35, 36].

Profound hearing impairment has a devastating effect on the development of oral speech production skills [37]. In general, the milder hearing impairment that is caused by otitis media is not associated with clinically significant delays in speech and language skills [38, 39]. However, otitis media during the first six months of life is associated with relatively poor speech discrimination skills [40] and delayed onset of speech-like babble [41] during infancy. A history of chronic otitis media may be associated with unexpectedly poor intelligibility and certain kinds of distortion errors in children's speech [42, 43].

Recent research indicates that there are large individual differences between infants in the ability to attend to speech, especially in noisy environments [44-46]. It seems possible that children who attend more carefully to speech will learn more about the acoustic-phonetic characteristics of different speech sound categories than children who do not attend as closely. Research that addresses this question is ongoing in my lab.

Brain imaging studies show that some newborn infants do not process speech in the normal way. Specifically it has been found that infants who are at-risk for dyslexia due to positive family history do not process syllable durations in the same way as newborns who are not at-risk [47]. Brain responses to speech sound contrasts in infancy were correlated with receptive language skills, verbal memory skills, and reading abilities at later ages [48]. Children with speech sound disorders and children with dyslexia share a common deficit in phonological processing disorders. Children with dyslexia are very likely to have had speech problems as preschoolers. Preschoolers with speech disorders are at higher risk for developing dyslexia than other children. Genetic overlap between these two groups has also been documented [49-51].

Some studies have also suggested that children with speech-language and/or reading problems have difficulty with the processing of nonspeech auditory stimuli [52] but these findings are less consistent and more controversial [53].

SPEECH ASSESSMENT AND INTERACTIVE LEARNING SYSTEM

IV. Evidence for the Validity of SAILS as an Assessment Tool

1. Content Validity

SAILS was initially developed as an intervention tool rather than an assessment tool. However, the structure of the program is such that it meets known criteria for valid assessment of speech perception. Locke [54] explained that the goal of a speech perception assessment should be to "determine whether there is a discrepancy between the speech forms the child is expected to acquire (that is, adult surface forms) and those already stored (that is, the child's internal underlying representations)." The SAILS task requires the child to determine whether each word presented is an acceptable token of a given word, and therefore the task is perfectly consistent with this goal. The table below lists the criteria for a valid test, as outlined by Locke [54, 55], and indicates how SAILS corresponds to these criteria.

Criterion	SAILS Characteristic
Test contrasts should correspond to child's error patterns.	The items were recorded from children and thus represent actual (rather than simulated) child substitutions for commonly misarticulated phonemes.
The test task should involve identification, rather than discrimination, of test items.	The child's task is to identify correct and incorrect productions of target words by pointing to a picture of the target word or to an 'X'.
The task should be developmentally appropriate.	The child is required to decide if a word corresponds to a target or not. The task is easily understood by children aged 4 or older. The child listens to only one stimulus word on each trial and thus the memory requirements are minimal (i.e., the child does not have to hold multiple words in memory and compare them). The task avoids the requirement to make 'same' or 'different' judgments, which are known to be difficult for preschool aged children.
The test should have multiple trials for each target phoneme.	Each phoneme module involves 10 to 30 test trials.
A control task should be included to ensure that the child is capable of performing the task.	Each module includes a practice module that contains stimuli that are easily identifiable.

2. Predictive Validity

Studies of children who are at familial risk for dyslexia have revealed a fundamental problem with speech processing that is apparent at birth in brain imaging studies and later in life in behavioral responses to speech perception tasks [47, 48]. Other studies have reported a close relationship between speech perception and phonological awareness and other literacy skills [56-58]. Therefore, relationships between SAILS performance and phonological awareness, and between SAILS and nonword decoding, would support the validity of SAILS as an assessment tool.

In a longitudinal study, children with speech sound disorders received an assessment of their perception of the phonemes /k/, /l/, /r/, and /s/, first during the year prior to kindergarten, again at the end of the kindergarten year, and finally at the end of first grade. It was found that children with a speech disorder showed significantly poorer speech perception and phonological awareness performance than children with typically developing speech, after matching these groups for receptive vocabulary skills [59]. Significant concurrent correlations between SAILS performance and phonological awareness were reported for 95 children with a speech sound disorder, tested during the prekindergarten year [17]. SAILS performance prior to kindergarten predicted improvements in phonological awareness performance during the kindergarten year. Subsequently, it was found that SAILS performance prior to kindergarten predicted significant variance in nonword decoding skills when the children were in first grade. This series of studies also demonstrated that severity of the speech delay and the nature of the children's speech errors were not reliable indicators of which children would have a phonological awareness deficit, placing them at risk for reading problems [60]. Speech perception skills as measure by SAILS were the primary predictor of these outcomes.

3. Reliability

Split-half reliability for SAILS performance over 70 trials and 4 modules (/k/, /l/, /r/, and /s/ modules) was .82 in the longitudinal study discussed above.

4. Description of Normative Sample

The tables in Section IV.5 show the mean scores (and standard deviations) obtained by 35 children recruited from daycares and preschools. The children were normally developing and spoke English as their first language according to their parents and teachers. Upon entry to the study, socioeconomic status was rated for each child's family by combining the parents' occupation and level of education to yield a Blishen score. The resulting Blishen scores ranged from 31 (high school not completed) to 101 (professional credentials), with a mean of 58 (some post-secondary education). Thirteen of the children attended French immersion schools. Goldman-Fristoe Test of Articulation percentiles were within normal limits (M=45.03; SD=18.53), as were Peabody Picture Vocabulary Test standard scores (M=112.43; SD=11.02). SAILS scores as obtained from these children during the three years of the study are shown in the 3 tables in Section IV.5.

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5. Normative Data

This data was collected towards the end of the school year. The mean score reflects the child's percent correct score, averaged across all of the test blocks for the module as shown (omit score for practice blocks). To determine if the child's performance is within normal limits, calculate the z-score using the following formula: (Child's score minus the Mean)/S.D. If the z score is less than -1, the child's performance is 'below normal limits'.

SAILS NORMS PREKINDERGARTEN (AGE 4.5 TO 5.5 YEARS)

Module	Mean	S.D.
/l/: lake	87.00	8.06
/k/: cat	78.60	7.17
/ɹ/: rat	79.46	10.92
/s/: Sue	71.52	8.64
All four	77.70	6.60

SAILS NORMS KINDERGARTEN (AGE 5.5 TO 6.5 YEARS)

Module	Mean	S.D.
/l/: lake	91.92	10.96
/k/: cat	77.31	10.79
/ɹ/: rat	82.31	8.51
/s/: Sue	80.26	8.38
All four	82.09	6.10

SAILS NORMS GRADE ONE (AGE 6.5 TO 7.5 YEARS)

Module	Mean	S.D.
/l/: lake	92.29	10.31
/k/: cat	81.43	12.87
/ɹ/: rat	85.70	12.61
/s/: Sue	81.24	7.59
All four	84.12	6.68

SPEECH ASSESSMENT AND INTERACTIVE LEARNING SYSTEM

V. Evidence for the Validity of SAILS as an Intervention

1. Rvachew (1994)

In the first study involving SAILS [61], 27 children aged 42 to 66 months participated. The children's receptive and expressive language skills were within normal limits but their articulation skills were moderately or severely delayed. All of the children were unstimulable for the target phoneme (/ʃ/) during pretesting.

The children were randomly assigned to three different treatment conditions. All of the children received 6 once-weekly treatment sessions. Each session began with 60 SAILS training trials, in which the child listened to words and identified them as being exemplars of the target word or not. Subsequently, 20 minutes of traditional articulation therapy, targeting the /ʃ/ phoneme were provided. The difference between treatment conditions lay solely with the nature of the stimuli presented during the speech perception training trials. Children in Group 1 listened to a variety of naturally produced exemplars of the word 'shoe', half produced correctly and half produced incorrectly. Children in Group 2 listened to a single well produced token of the word 'shoe' and a single well produced token of the word 'moo', each token being presented 30 times. Group 3 children listened to the words 'cat' and 'Pete'. Children in Groups 1 and 2 were instructed to point to a picture of 'shoe' when they heard to word 'shoe'. Children in Group 3 pointed to a picture of a 'cat' when they heard the word 'cat'. The SAILS training trials were presented by a research assistant and the articulation therapy sessions were conducted by a speech-language pathologist. Post-treatment speech samples were transcribed by speech-language pathologists who did not know which condition the child was assigned to.

Group 1 demonstrated the greatest improvement in speech perception performance but Group 2 also showed significant gains in speech perception ability. Group 3 did not show any improvement in speech perception scores between the pre- and post-treatment assessments. With respect to improvements in speech production ability, few children progressed beyond the imitated word level for accurate production of /ʃ/ as might be expected given the young age of the participants and the difficulty of the target phoneme (recall that all children were unstimulable). However, Group 1 children made significantly more progress than Group 2 children who made significantly more progress than Group 3 children. In fact, only one child in Group 3 achieved stimulability for the target phoneme in isolation. On the other hand, 6 children in each of Groups 1 and 2 achieved stimulability in isolation and some children in Group 1 achieved mastery at the spontaneous sentence level.

One explanation for the success of the SAILS intervention in this study is that the children developed a strong internal representation for the /ʃ/ phoneme that allowed them to monitor the accuracy of their own productions and self-correct their errors. Parents of children in Group 1 reported that their children engaged in self-practice when alone (i.e., in the bath-tub, in the back seat of the car, before falling asleep).

2. Rvachew, Rafaat, & Martin (1999)

In the next study [62], a non-experimental comparison of the cycles approach, with and without the inclusion of the SAILS intervention, was conducted. In the first year of this study, children received 12 weeks of small group therapy modeled after the cycles approach [63]. Prior to the onset of the intervention the children's stimulability and perceptual knowledge of the target phonemes was assessed. Measurable improvements in production accuracy for these targets were observed if the child was stimulable for the sound and/or had good perceptual knowledge of the targeted phoneme category prior to treatment. When the child's speech perception performance for the target phoneme was poor or the child was unstimulable for the target, gains were unlikely to occur. Overall measurable gains in production accuracy were observed for only 40% of the phonemes that were targeted during the 12 week intervention.

In the second year of this study, children again received a small group intervention modeled on the cycles approach. However, in this year, the first three group sessions were replaced with a 10 minute session of individual therapy during which phonetic placement was used to ensure stimulability of treatment targets, and SAILS was used to ensure good perceptual knowledge of the target phonemes. Post-treatment, improved performance was observed for 80% of all treatment targets, regardless of pretreatment level of speech perception skills and stimulability.

3. Rvachew, Nowak, & Cloutier (2004)

The next study also involved preschool aged children with moderate or severe speech sound disorders [64]. Thirty-four children received 16 once-weekly treatment sessions. These sessions were conducted by speech-language pathologists who were free to use any approach to speech therapy that they felt was appropriate. After each speech therapy session the child went with an undergraduate student research assistant for 10 minutes of work with a computer game. The experimental group received the SAILS intervention, targeting a different phoneme each week, in word initial position during the first 8 weeks and in word final position during the last 8 weeks. The control group listened to computerized books and answered questions about the pictures. The speech-language pathologists who were responsible for the children's speech therapy programs were not aware of the intervention that was provided by the research assistant during the final 10 minutes. Speech samples were recorded pre- and post-treatment by a speech-language pathologist who was not involved in the child's speech therapy program and who was not aware of the whether the child was in the experimental or control group. Improvements in standardized articulation test scores and percent consonants correct in conversation were significantly greater for the experimental group than for the control group. Follow-up testing one year later when the children were in kindergarten revealed that 50% of the experimental group achieved normalized speech prior to first grade entry in comparison with 19% of the control group.

Recent reviews of these studies have concluded that scientific support for the efficacy of SAILS is excellent [65, 66]. The use of the SAILS intervention significantly boosted children's response to standard speech therapy approaches even though the time devoted to the SAILS intervention was limited in each case (i.e., 60 minutes, 30 minutes, and 160 minutes in the three studies described above).

VI. When is it Appropriate to Use SAILS?
    1. Nature of the child's communication deficit
    2. Age of child
    3. Who should administer the SAILS intervention?
    4. How should SAILS be integrated with other treatment procedures?
    5. Are there effective substitutions for the SAILS program?
    6. Language and dialect considerations

VI. When is it Appropriate to Use SAILS?

1. Nature of the child's communication deficit

SAILS was developed for use with children who have a speech sound disorder of unknown origin that has its onset during the preschool period. Furthermore, it was meant to be used in conjunction with a speech therapy program that has the goal of improving articulatory accuracy for specific speech sounds. The research reviewed in Section V suggests that the program is most effective when the child's speech perception skills are poor prior to treatment for a given target sound [28, 67].

There are other categories of speech sound disorders that may or may not benefit from the SAILS approach. For example, some children progress through the preschool period with age-appropriate speech but show persistent distortion of late developing sounds after school entry. These children with residual errors have been found to have difficulties with accurate perception of their error sounds and thus may benefit from SAILS or other speech perception training activities. However, this has not been demonstrated in a randomized study.

Children with speech differences due to exposure to other languages are also very likely to misperceive the sounds that they misarticulate. For example, children whose first language is French or Spanish may show misperception and misarticulation of sound contrasts such as [d]-[ð]. However, the speech stimuli in the SAILS program were not recorded from such children and thus these stimuli may not reflect the kinds of perceptual difficulties that these children experience. This is another population for whom direct evidence of a treatment benefit is lacking.

Children with specific language impairment and/or dyslexia are known to have difficulty with speech perception [57, 58]. However, there is no evidence that SAILS will be helpful when the goal is to improve a child's vocabulary, grammar, phonological awareness, or decoding skills. Therefore, pending further research, SAILS is not recommended for use with these groups unless your goal is to improve the child's articulation of a phoneme that is targeted by SAILS.

2. Age of the child

The children who have been involved in the studies reviewed here were 4- or 5-years old. The graphics and game characteristics of the SAILS program were designed for young children and may not be appreciated by older children, even though these children may benefit from a speech perception approach. Younger children find the task difficult and thus a focused stimulation approach is more likely to be effective with toddlers and young preschoolers [68].

3. Who should administer the SAILS intervention?

In section V, three studies were described that tested the efficacy of the SAILS intervention to improve children's speech production skills. In these studies the program was provided by a communication assistant or a research assistant or the child's parent supported by a research assistant. The assistants were trained to provide appropriate feedback to the child (see Section VII) when he or she pointed to the wrong response alternative.

4. How should SAILS be integrated with other treatment procedures?

SAILS should be integrated with procedures for teaching correct articulatory placement and promoting frequent speech production practice. Thus far, the program has proven effective when combined with a traditional approach to articulation therapy and the cycles approach to phonological therapy.

It is probably best if the SAILS target be the same as or similar to the specific sound that is being targeted for speech production practice. For example, if you are using a traditional

approach to target /s/ production, your sessions could begin with a few minutes of practice identifying the word 'soap' using the SAILS program. If you are targeting 'stopping of fricatives'

as an intermediate goal and the phonemes /f, v, ʃ, s, z/ as your specific goals, you could cycle through the SAILS modules for 'feet', 'shoe' and 'soap'.

One prior study involved providing the same sequence of SAILS lessons to all children regardless of their individual errors [64]. However, the children who participated in this study produced very many speech errors on average and thus most of the SAILS targets corresponded to the phonemes that were being targeted by their SLPs for production practice.

SAILS has proven to be effective in studies in which each SAILS practice session lasted between 5 and 10 minutes (4 and 5 year old children can easily complete about 60 trials in one sitting). It may not be necessary to continue with SAILS for as long as it takes to achieve mastery of accurate sound production. As I have described elsewhere [69], I like to provide SAILS practice at the beginning of the treatment program in concert with stimulability training (i.e., phonetic practice and syllable drills) and then again later in the treatment program if the child is having difficulty generalizing correct production to spontaneous speech or if the child is showing evidence of overgeneralization.

There are some other computer based resources for articulation therapy that may be useful adjuncts to the SAILS program. Learning Fundamentals offers a number of products in the LocuTour Articulation CDs series that are useful for articulation practice [http://www.learningfundamentals.com/products/]. The child is provided with a spoken model of a word or sentence for imitation. The child's response is recorded so that the model and response can be compared. Ensuring that the child has good perceptual knowledge of the target should help the student succeed at the self-monitoring task.

Many case studies have suggested that visual feedback may be useful for helping children to achieve correct articulatory placement. Within the context of the theory of speech motor control that was discussed in Section III, a strong underlying representation for the target phoneme is critical to the development of accurate speech. SAILS may enhance responsiveness to visual

feedback approaches, including spectrographic feedback [70, 71], electropalatographic feedback [72, 73] and ultrasound images [74, 75].

5. Are there effective substitutions for the SAILS program?

Some commonly used speech therapy procedures have the goal of improving the child's phonological knowledge of phoneme contrasts. For example, the minimal pairs procedure can be used to highlight the linguistic significance of a contrast that the child collapses in productive speech [76, 77]. Other approaches emphasize acquisition of metaphonological knowledge of phoneme contrasts [78]. Recently we have assessed the effectiveness of SAILS in an intervention with French-speaking children using an "input-oriented approach" that included live-voice ear training procedures, minimal pairs therapy, a small group phonological awareness intervention and parent administered dialogic reading. We were very pleased with the results for speech accuracy and phonological awareness [82, 83].

Van Riper's approach to articulation therapy was structured so that a period of 'ear training' was provided before the introduction of production practice activities [79]. The 'ear training' phase involved four procedures: identification, isolation, stimulation, and discrimination. *Identification* procedures include communicating the purpose of the therapy program to the child and demonstrating the acoustic and articulatory properties of the target sound. This is a good practice regardless of the approach to intervention that is being used. The *stimulation* procedure is the same as the auditory bombardment procedure that is used routinely with the cycles approach [63]. The discrimination procedure is exactly like SAILS except that the SLP presents the stimuli live voice, contrasting correct versions of the phoneme with simulations of the child's error. These procedures are fully consistent with the theoretical perspective that was outlined in Section III. The usefulness of these procedures has been questioned in the past, however. In one study, these procedures were not found to be effective when administered by parents [80]. It seems likely that SAILS is more effective than these live-voice procedures because the stimuli are more variable. As explained in Section III, stimulus variability is an important component of effective speech perception training. Furthermore, the full range of SAILS stimuli was shown to be more effective than a restricted set of stimuli in a small randomized control trial [61]. Also note that all of the studies involving SAILS have provided the SAILS activities concurrently with speech production training rather than in separate 'ear training' and production practice phases. More research is required to test the hypothesis that the traditional approach to speech therapy will be more effective when SAILS is substituted for live-voice ear training procedures.

6. Language and dialect considerations

The SAILS stimuli were recorded from children who speak Western Canadian English as their native language. The program will not be appropriate for children who speak markedly different dialects of English. Please contact Dr. Susan Rvachew for assistance if you wish to create stimuli for children who speak different languages or dialects or children who produce unusual error patterns that are not represented by the SAILS stimuli.

VII. Tips on the Use of the SAILS-2 Software
    1.   Maintain control of the mouse.
    2.   Disable the auditory feedback.
    3.   Don't rely on the visual feedback to reinforce correct responses.

VII. Tips on the Use of the SAILS-2 Software

1. Maintain control of the mouse.

SAILS allows independent use of the program by the child. However, I prefer that an adult mediate the child's experience with the software. In the studies described in Section IV, the child has been instructed to point to the appropriate response alternative on the screen, and the adult used the mouse to 'click' on the picture when the child pointed to the correct alternative. If the child points to the incorrect response alternative, you can provide additional instructions and re-present the stimulus to the child. Although the software can inform the child if he or she has made an incorrect response, the software cannot explain the nature of the error. If you sit with the child, you can provide more informative feedback that is personalized for a given child. If your client tends to confuses stops with fricatives you might provide different feedback than if your client produces a dental distortion for the fricatives.

2. Disable the auditory feedback.

If you want the child to play the game without your assistance, auditory feedback can be provided by the program. However, if you wish to sit with the child and provide your own feedback in the case of child error, you should disable this feature.

3. Don't rely on the visual feedback to reinforce correct responses.

SAILS also provides visual feedback for correct responses – specifically when the correct response alternative is 'clicked', a new item is added to the scene shown on the left side of the screen. This feedback may serve as reinforcement for correct responses when the child is playing alone. Providing reinforcement without information however can be counterproductive because in some circumstances, external reinforcers undermine the child's intrinsic interest in an activity [81]. It is best to allow the child to experience the intrinsic rewards that are associated with achieving specific goals and mastering a new skill. This is one reason that I prefer to prevent incorrect responses and provide informative feedback as described in VII.1. This reasoning also explains the rather 'muted' nature of the visual feedback that is provided – the addition of the item to the scene occurs quickly without much fanfare and doesn't distract the child from the task at hand. The feedback pictures were intended to serve as a counter or an indication of the passage of time. Young children are more likely to engage in drill activities if they have some idea of how long the activity will last. Telling a child that they must engage in the activity for 2 minutes or 10 minutes is not very meaningful to young children because they are poor judges of the passage of time. However, if you tell the child that they will play the game until some number of scenes are completed, they will learn to judge how quickly a module will pass. As they gain experience with the scenes, they will know when a module has been completed. Therefore, these pictures provide information to the child about the achievement of a goal as well as helping them to judge how long an activity will last.

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