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Acquired Apraxia of Speech: Evidence-Based Intervention
Introduction: Empirical Support for Treatment of Acquired Apraxia of Speech

This issue of the Division 2 Newsletter is devoted to the discussion and review of evidence supporting the use of various treatments for acquired apraxia of speech (AOS). The field of AOS treatment research is relatively new, in that the first published reports of treatments for AOS appeared in the early to mid-1970s (Keith & Aronson, 1975; Rosenbek, Lemme, Ahern, Harris, & Wertz, 1973). Since that time, a variety of treatment methods have been discussed (see McNeil, Doyle, & Wambaugh, 2000, for a review). Investigators have been slowly, but consistently, making progress in the evaluation and refinement of AOS treatments. Researchers have moved from reporting uncontrolled case studies to employing experimental methods to assess treatment effects. In considering Robey’s (2001) discussion of the typical stages involved in the development of evidence-based treatments, the field of AOS treatment research could be described as being in the early stages of evaluating “efficacy.”

Although numerous approaches have been proposed for the treatment of AOS, we will focus on two treatment methods that have received significantly more research attention than others: Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT; Square, Chumpelik, & Adams, 1985) and Sound Production Treatment (SPT; Wambaugh, Doyle, Kalinyak, & West, 1996). In the first article of the issue, Arpita Bose and Dr. Paula Square review the basic principles and methods underlying PROMPT. They then present the evidence supporting the use of PROMPT along with a discussion of the need for additional research. Similarly, in the second article, I review the procedural aspects of SPT and summarize the research supporting its use.

The third and fourth articles of the issue move away from discussions of specific treatment protocols to discussions of aspects of treatment that deserve serious consideration when applying almost any AOS treatment. Dr. Kirrie Ballard discusses principles of motor learning that appear to be pertinent to the treatment of AOS, such as structure of the practice session, type and frequency of feedback, and transfer between part and whole task components. She reviews not only the sparse literature in speech-language pathology, but also the literature in limb motor learning. Dr. Linda Shuster then focuses on the issue of utilizing oral motor training in the treatment of AOS. She reviews the literature that examines the relationship between non-speech oral abilities and speech abilities.
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to determine if evidence supports the use of non-speech tasks in the treatment of AOS.

In the final article, Dr. Margaret Rogers presents convincing arguments urging clinicians and researchers to consider augmentative and alternative communication approaches for individuals with moderate or severe AOS. Additionally, Dr. Rogers addresses the extremely important issue of adequately defining and documenting AOS in study participants. Beyond the AAC/AOS literature, the entire existing AOS treatment literature is replete with inadequate participant descriptions. Consequently, evaluation of existing treatment data is difficult and generalization of findings is almost impossible. As correctly noted by Dr. Rogers, this issue continues to be a major obstruction in the development of evidence-based AOS treatments.

The topics discussed in this issue represent only a sampling of the available AOS treatments and concerns that clinicians must consider in their management of AOS. The road to providing clinicians with thoroughly tested AOS treatments is long. Although progress has been made in demonstrating positive treatment effects with selected approaches, there is an obvious need for systematic, sustained evaluation of treatments across individuals with varying severities of AOS.

References


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PROMPT Treatment Method and Apraxia of Speech

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Introduction

Acquired apraxia of speech (AOS) is a neurogenic speech disorder that is characterized by speech sound errors, slowed rate of speech production, and disrupted prosody (Square, Martin, & Bose, 2001). The speech difficulties observed with AOS are considered to arise from disturbances in the specification of the temporal and spatial aspects of speech sound production (McNeil, Doyle, & Wambaugh, 2000). That is, AOS is thought to reflect a disrupted speech motor system.

Basic Principles and Method

Facilitation of the speech motor system of individuals with apraxia of speech (AOS) can be provided in a variety of ways, including tactile and kinesthetic support (see Square, Martin, & Bose, 2001) or melodic and rhythmic methods (Sparks & Deck, 1986; Square, Roy, & Martin, 1997). Prompts for Restructuring Oral Muscular Phonetic Targets (PROMPT) is a tactile-kinesthetic-based treatment method that employs components of both articulatory/kinematic and rhythmic/rate control strategies in the treatment of AOS. This method was originally developed by Chumpelik (1984) for the treatment of children with developmental motor speech disorders and has subsequently been modified and effectively employed with adults with motor speech disorders (Square-Storer & Hayden, 1989). The oral-facial cues/prompts are targeted to guide the client through the temporal and spatial aspects of speech movements using a combination of proprioceptive, pressure, and kinesthetic cues. These cues are designed to heighten sensory input regarding the place of articulatory contact, extent of mandibular opening, presence and extent of labial rounding and

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retraction, voicing, muscle tension, timing of segments, manner of articulation, and/or coarticulation. As a method, PROMPT helps the client to gain voluntary control of the motor speech system and links the necessary motor movements that help create holistic motor-phoneme maps to linguistic equivalents for use in communication (Hayden, 1999). That is, PROMPT is considered to facilitate the translation of articulatory–kinematic parameters of speech production to the corresponding phonemes and, further, to the resultant words and phrases intended for production.

Hayden and Square (1994) developed the Motor Speech Hierarchy that guides the PROMPT system for both assessment and treatment of motor speech disorders. This hierarchy focuses on the training and use of appropriate degrees of freedom and boundaries for speech movements in the overall speech system and speech subsystems (jaw, labial-facial, lingual) in a hierarchical fashion.

The first two stages of the hierarchy focus on neuromuscular pretuning for speech and are usually normal in individuals with AOS, but usually abnormal in individuals with dysarthria. Stage I focuses on postural support for speech and emphasizes the attainment of trunk, neck, and head control and the suppression of abnormal oral-motor reflexes. Stage II focuses on phonatory control that will support speech for at least 2-3 seconds.

Stages III, IV, and V of the Motor Speech Treatment Hierarchy assess the three supralaryngeal articulatory subsystems: jaw, lips, and tongue. These articulatory subsystems may be affected individually or in combination with each other in various degrees of severity. Stage III focuses on the control of jaw movements that are appropriate in speech. Horizontal and anterior-posterior jaw sliding are physically inhibited by the clinician. Maximal jaw opening for “normalized” speech is established, in that the degree of opening of the jaw is physically restricted by the clinician so that the opening does not exceed that required for /a/ in connected speech. Control over jaw gradation is then established using appropriate words that contain vowels and consonants that require consistent use of degrees of jaw opening. At Stage IV of the hierarchy, symmetry of movement on both sides of the face and coordinated movement of the upper and lower lips are encouraged through physical manipulation in speech. Labial refinements occur at Stage IV and are integrated with jaw control to develop more complex movement synergies between the two subsystems. Once jaw and labial parameters of action are normalized and integrated, Stage V is introduced. In Stage V, anterior and posterior tongue action, as well as control of tongue height and location and area of contraction along the tongue body, are established and then integrated with jaw and labial movements.

Stage VI of the hierarchy focuses on increasing precise control of parameters of the supralaryngeal articulators (e.g., direction or extent of articulator movement) within longer sequences of speech movements. At this level, prompts that indicate key elements of movement at points of natural stress may be used (e.g., slight pressure on the lips when there is a stressed word). Finally, in Stage VII, temporal aspects of speech production, such as appropriate rates and intonation contours, are practiced. Given that speech is a very complex action, the clinician may need to work on more than one stage at any one time. On the other hand, movement impairment could be at only one stage (e.g., lip and facial muscles); in that case, the clinician might work at a single stage. In the PROMPT method, the clinician can work at one or more stages depending upon the needs of an individual client and his/her impairments.

The stimuli employed in each stage of PROMPT are dependent upon the individual’s speech motor problems and specific goals. Consequently, PROMPT can be used to cue speech segments at the phoneme, word, or phrase level (Square-Storer & Hayden, 1989) or to facilitate only certain parameters of movements, such as jaw opening or the temporal flow of multi-syllabic utterances (see Square et al., 2001, for discussion). Hayden (1999) detailed three types of prompt cues depending upon the type of support required by the speech motor system. First, “parameter prompts” are larger organizing and supporting postures that provide support for control of speech movements in specific subsystems. For example, if the client presents with an overall retracted facial posture (i.e., facial muscles are contracting and presents with a perpetual smile), then the parameter prompt would help release the muscle contraction and allow a more relaxed and rounded facial position from which move-
ment for speech can begin. Second, “complex prompts” are more intricate cues that signal the place, length, and intensity of contractions and provide as much information as possible about the motor-phoneme map (i.e., they are based on the motor templates of phonemes). For example, the complex prompt for the vowel /i/ would include input to the anterior portion of the mylohyoid muscle resulting in contraction of the front of the tongue as well as input to the orbicularis oris muscle resulting in contraction to create a retracted facial position. Third, “surface prompts” provide the least amount of tactile-kinesthetic input and provide information about timing and transition of varying planes of movement, particularly in multisyllabic utterances. For example, the surface prompts for both /m/ and /i/ would be used to help with the timing involved in the transition from one sound to the other in the word (e.g., “me”). (For detailed discussion on different types of prompts see Square et al., 2001).

**Clinical Studies/Empirical Evidence**

Even though PROMPT has been used clinically for a number of years with AOS speakers, there are few experimental studies that have investigated responses to PROMPT treatment. Square and colleagues (Square, Chumpelik, & Adams, 1985; Square, Chumpelik, Morningstar, & Adams, 1986; Square-Storer & Hayden, 1989) have reported the positive effects of PROMPT in 4 adults with AOS and coexisting aphasia. In these studies, PROMPT treatment was used to train subjects to produce minimally contrastive phonemes, polysyllabic words, and short phrases. Positive results were reported for all target behaviors for the subjects, with varying degree of generalization. Four subjects demonstrated better production abilities in trained phonemes and words, while 3 of the 4 subjects showed improvement in functional phrases. In addition, the subjects also demonstrated improvement in speech intelligibility as measured by the Assessment of Intelligibility of Dysarthric Speech (AIDS, Yorkston & Beukelman, 1981). There was some generalization to untrained items, but performance was variable. The results of these investigations were encouraging, particularly because positive treatment effects were demonstrated even for speakers with very severe AOS. Unfortunately, these preliminary studies utilized a very limited number of training utterances and subjects and employed an uncontrolled simultaneous treatment design to demonstrate effects and to compare PROMPT with other treatment methods (e.g., integral stimulation).

Freed, Marshall, and Frazier (1997) examined the effects of PROMPT treatment in an adult with severe AOS and aphasia using a multiple-baseline across behaviors design. The treatment items consisted of a core vocabulary of 30 words and short phrases that were functionally and personally relevant to the participant. Treatment was employed sequentially for six separate lists, each containing five items, over a period of 41 weeks. Results revealed robust acquisition of all 30 items with strong maintenance effects. There was some variability in performance across lists. Although there was no formal measure of generalization, the subject was encouraged to practice the vocabulary in appropriate social contexts. It was reported that the subject could successfully use the learned vocabulary spontaneously in appropriate contexts. In addition to the positive effects during the acquisition phase of treatment, this investigation highlighted the long-term maintenance of the treatment gains and the importance of utilizing the trained utterances in socially appropriate contexts.

In a more recent investigation Bose, Square, Schlosser, and van Lieshout (2001) examined the effectiveness of PROMPT treatment on the acquisition and generalization of precision and automaticity of speech movements in an individual with AOS and Broca’s aphasia. Using a single subject multiple probe design across behaviors, treatment effects and generalization were examined for 30 functionally and personally relevant short phrases (15 training and 15 generalization) grouped in five items each in three linguistically different forms of sentences: imperatives, active declaratives, and interrogatives. The speaker participated in one hour treatment sessions three times a week over a period of 7 weeks. Results indicated improved speech precision and sequencing of speech movements for trained and untrained sentences for imperative and active declarative forms only. There was no effect of treatment on the interrogatives. The results of this study indicated that for this individual with AOS and aphasia, PROMPT treatment was more effective for linguistically simpler utterances, thus highlighting the fact that careful consideration should be
given while constructing treatment stimuli for such clients. In addition, results indicated that PROMPT could be used to improve articulatory ease and proficiency for individuals with moderate AOS and aphasia.

**Evaluation**

Overall, clinical observations and studies examining effects in 6 participants suggest that PROMPT can be an effective treatment method for speech motor impairments in AOS. Studies demonstrate that speakers with even severe AOS can acquire functional vocabularies and use them in social contexts and suggest that, with extensive practice, treatment gains may be maintained over a long period of time. For clients with less severe impairments, articulation can improve even with short durations of treatment. Despite the usefulness of this method, the practicing clinician should note the following:

- First, extensive clinical training and practice is required to master PROMPT before it can be used effectively. Delivering appropriate PROMPTs for improving articulation requires practice and patience on the part of clinicians.
- Second, intensive practice is required from the client in order to maintain gains and make the effects generalizable to different situations.
- Third, even though the PROMPT system is based on the Motor Speech Hierarchy, none of the clinical studies to date has followed the hierarchy to develop treatment goals. This is in part due to the fact that speech (words and utterances) is produced by the complex integration of various subsystems (articulators), and it is difficult to construct stimuli that focus on just one subsystem of speech (e.g., jaw control), yet maintain functional and personal relevance for the client. As recommended by Hayden and Square (1994), more than one subsystem can be worked on simultaneously if required.
- Fourth, PROMPT involves frequent touching of clients’ face and articulators by the clinician. Some clients may show high tactile sensitivity. Both clients and clinicians may not be fully comfortable with such intervention.

As demonstrated in the preceding paragraphs, there is limited information on effectiveness and efficacy of treatment using the PROMPT system for clients with AOS. This is attributable, in part, to the fact that this method to treat adults with AOS is relatively new in the whole scheme of treatment approaches and still requires development and refinement. Nevertheless, the existing clinical case studies and single subject studies do demonstrate the positive effects of the PROMPT system.

The current state of knowledge warrants that additional efficacy research be undertaken. Such research should be designed with the following considerations:

- The effectiveness of the PROMPT treatment should be investigated both in isolation and in combination with other treatment methods for AOS;
- The relative effectiveness and efficiency of PROMPT should be compared to other treatment methods;
- Well-controlled designs should be employed to assess the specificity of the treatment and generalizability to a broad variety of situations and contexts;
- Sample size should be increased and should include a variety of participants, using carefully selected inclusion and exclusion criteria; and
- Research should seek to identify the optimum schedule of treatment delivery to enhance learning and maintenance of motor skills.

**References**


Acquired apraxia of speech (AOS) is a neurogenic speech disorder that is considered to reflect an underlying disruption of the ability to specify speech motor programs (McNeil, Robin, & Schmidt, 1997; McNeil, Doyle, & Wambaugh, 2000). The sound errors that typify AOS are errors of spatial targeting and timing of the articulators (Square, Martin, & Bose, 2001). Consequently, treatments for AOS frequently focus on facilitating or improving the articulatory-kinematic aspects of speech production (McNeil et al., 2000). Sound production treatment (SPT) is one such treatment that has been systematically investigated in terms of its effects on consonant production in speakers with AOS.

**Procedures**

SPT was designed to promote correct production of specific sounds targeted for intervention. Treatment combines modeling, repetition, minimal pair contrast, integral stimulation, articulatory placement cueing, and feedback. With the exception of minimal pair contrast, these techniques are traditional articulation training techniques that have been shown to have positive effects in speakers with AOS (Wertz, LaPointe, & Rosenbek, 1984; Rosenbek, Lemme, Ahern, Harris, & Wertz, 1973). Although the use of minimal pair contrast is more commonly associated with facilitating phonological development than with promoting correct articulation, it has been incorporated into SPT for several reasons. Despite observations that the majority of AOS sound errors appear to be motoric in nature (McNeil et al., 1997; McNeil et al., 2000), it is possible that some sound errors produced by speakers with AOS and aphasia may be phonological in nature. Minimal contrast pairs may provide facilitory effects to sound selection through homonymy avoidance (i.e., sound differentiation is necessary in the production of minimal contrast pairs in order that the word pairs do not sound the same). Additionally, minimal contrast practice involving the target sound and the replacing sound provides potentially important practice in detailing the articulatory parameters (i.e., movement specifications) needed to differentiate the sounds.

The techniques that comprise SPT are applied in a response-contingent hierarchy. That is, subsequent steps of the hierarchy are utilized only upon an incorrect response. The basic steps of the hierarchy are as follows:

1. The clinician provides a verbal model of the target sound/word/phrase/minimal pair and requests that the speaker repeat the target. If the response is correct, the clinician provides positive verbal feedback, requests another repetition of the target and then presents the next item. This procedure is followed in all of the following steps when a correct response is provided. Feedback at this step (and subsequent steps, with the exception of Step 4) takes the form of knowledge of results (Schmidt & Lee, 1999).

2. If the response is incorrect, the clinician provides appropriate feedback, presents a written letter corresponding to the target sound (i.e., “this is the sound you are working on”) and repeats Step 1.

3. If the response is incorrect, the clinician provides feedback and asks the speaker to attempt the target utterance with integral stimulation (i.e., watch me, listen to me, say it with me). A maximum number of attempts is specified (usually three to five attempts).

4. If the response is incorrect, the clinician provides articulatory placement cues specific to the sound error (cues may be verbal, visual, tactile).

5. If the response is incorrect, the target sound may be attempted following a model in a simplified context, depending upon the original target (i.e., if working at the word level of production, the sound may be attempted in isolation; if working at the phrase level of production, the sound may be attempted in a word level production).

6. If the response is incorrect, the next target is attempted.

Eight to ten exemplars (e.g., words, phrases) containing the target sound are usually used for treatment. Each exemplar is submitted to the hierarchy in random order until all exemplars have been attempted.
Evidence for SPT Effectiveness

The empirical support for use of SPT rests on a series of single-case experimental analyses that have focused on explicating its acquisition, response generalization, stimulus generalization, and maintenance effects (Table 1, on page 13). Acquisition refers to correct production of trained behaviors in contexts similar to treatment. Response generalization relates to increases in untrained behaviors as a result of training a similar behavior. Response generalization effects of SPT have been measured to: (a) untrained exemplars of trained behaviors and (b) untrained, but related behaviors. Stimulus generalization concerns use of trained behaviors in untrained contexts. Maintenance refers to the durability of changes in behaviors after cessation of treatment and has been measured during training of subsequent behaviors and following completion of all treatment. In all of the following SPT investigations, probe data served as the indicators of treatment effects, with probes being conducted at least one day following a given treatment session.

Wambaugh, Kalinyak-Fliszar, West, and Doyle (1998) investigated the effects of SPT with 3 speakers with chronic aphasia and moderate to severe AOS. They used a multiple baseline design across behaviors and subjects and treated three sounds sequentially with each speaker (e.g., Speaker 1 received treatment first for /z/, then for /f/, and finally for /d/). Increases in correct production of trained items were demonstrated for each speaker with all sounds, although criterion levels of performance were not reached for one sound for two of the speakers (in both cases, the sound was /z/). Response generalization to untrained exemplars of trained sounds was strong, with correct productions paralleling those of trained sounds. Response generalization to untrained sounds was minimal. Stimulus generalization, production of trained items in untrained phrases, was positive for one speaker (for all sounds) and negligible for the other speakers. Maintenance effects were measured during training of subsequent behaviors and at 6 weeks following completion of all treatment. Maintenance data revealed that for 2 speakers, correct productions remained high for those sounds that had reached criterion levels of performance during treatment. For the third speaker, performance remained high for one sound, decreased by approximately 20% for a second sound, and returned to baseline levels for the sound that had not reached treatment criterion levels.

Wambaugh and Cort (1998) further examined response generalization effects of SPT with another speaker who presented with moderate AOS and Broca’s aphasia. They speculated that response generalization effects across sounds would be evident when error patterns were similar across those sounds. The speaker in their investigation demonstrated a single error pattern of devoicing across stops and affricates. The investigators hypothesized that improvement in production of voicing of one sound might result in improvement of voicing of untreated sounds. Treatment was applied first to /b/, then to /d/, and finally to /d/ and /g/ (simultaneously) in the context of a multiple baseline design across behaviors. Additionally, productions of /θ/ were measured for experimental control purposes. The speaker’s erroneous productions of /θ/ involved a spatial targeting error (i.e., perceived /f/ substitution) and therefore, were expected to be resistant to generalization effects. During treatment of /b/, modest improvements in productions of /d/ and /g/ were observed (i.e., improvements in accuracy of 20% to 45%). Productions of /b/ reached high levels of accuracy during treatment. When treatment was extended to /d/, additional improvements in /d/ and /g/ were observed (i.e., improvements in accuracy of 20% to 45%). Productions of /b/ reached high levels of accuracy during treatment. When treatment was extended simultaneously to /d/ and /g/ and relatively little improvement was observed with either sound. This may have been due to the fact that performance levels were
Table 1. Summary of Investigations of Sound Production Treatment

<table>
<thead>
<tr>
<th>Study</th>
<th>Purpose of Study</th>
<th>Design</th>
<th>N</th>
<th>AOS &amp; Aphasia</th>
<th>Dependent Measures</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wambaugh, Doyle, Kalinyak, &amp; West, (1996)</td>
<td>To examine response &amp; stimulus generalization effects of tx.; to examine relationship between probe &amp; tx. data; Participant also reported in 1998 study – additional data reported in 1996 investigation</td>
<td>MBD across behaviors</td>
<td>1</td>
<td>mod-severe AOS; Broca’s aphasia</td>
<td>% correct production of target sounds in trained &amp; untrained words &amp; in different stimulus contexts; follow-up at 6 weeks post-tx; measured in probes</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh, Kalinyak-Fliszar, West, &amp; Doyle, (1998)</td>
<td>To examine acquisition, response gen., stim. gen. &amp; maintenance effects of tx. To provide replications of tx. effects.</td>
<td>MBD across behaviors &amp; subjects</td>
<td>3</td>
<td>mod-severe AOS; Broca’s aphasia</td>
<td>see above</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh West, &amp; Doyle, (1998)</td>
<td>To examine the effects of training several sounds within a sound class simultaneously. To examine the effects of treatment on sound accuracy and rate of production.</td>
<td>MBD across behaviors</td>
<td>1</td>
<td>mild-mod. AOS; Broca’s aphasia</td>
<td>% correct sounds in trained and untrained sentences; follow-up at 6 wks. post-tx. sentence duration measures; measured in probes</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh &amp; Cort (1998)</td>
<td>To examine the response generalization effects of training on sounds for which error patterns were similar. To provide replications of tx. effects.</td>
<td>MBD across behaviors</td>
<td>1</td>
<td>mod. AOS; Broca’s aphasia</td>
<td>% correct sounds in trained and untrained words; measured in probes</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh, Martinez, MacNeil, &amp; Rogers, (1999)</td>
<td>To examine overgeneralization To provide replications of tx.</td>
<td>MBD across behaviors</td>
<td>1</td>
<td>mod.-severe AOS; Broca’s aphasia; dysarth.</td>
<td>% correct sounds in trained and untrained words; measured in probes</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh &amp; Martinez (submitted)</td>
<td>To attempt to mini-mize overgeneral-ization effects with the speaker from Wambaugh et al. (1999)</td>
<td>MBD across behaviors</td>
<td>1</td>
<td>mod.-severe AOS; Broca’s aphasia; dysarth.</td>
<td>% correct sounds in trained and untrained words; measured in probes</td>
<td>acq-positive</td>
</tr>
<tr>
<td>Wambaugh (2000, 2001)</td>
<td>To examine and promote stimulus generalization</td>
<td>MBD across behaviors</td>
<td>2</td>
<td>1-mod.-severe 1-mild-moderate</td>
<td>% correct sounds in words and phrases; measured in probes</td>
<td>acq-positive</td>
</tr>
</tbody>
</table>

AC: Accompanying Conditions
MBD: Multiple Baseline Design
acq: acquisition
rg(ue): response generalization to untrained exemplars
rg(us): response generalization to untrained sounds
sg: stimulus generalization
m: maintenance
high prior to the initiation of treatment with these sounds or to difficulty on the participant’s part in dealing with two sounds concurrently. Across sound generalization to /Ø/ did not occur. As in the Wambaugh et al. (1998) study, response generalization to untrained exemplars of trained sounds was strong. Maintenance effects were also strong.

Generalization of treatment effects across sounds was examined in the preceding studies from the perspective of assessing positive effects of treatment. Generalization effects may also be negative, as in the case of overgeneralization (i.e., incorrect overuse of trained behaviors). Wambaugh, Martinez, McNeil, and Rogers (1999) conducted an error analysis of responses in order to try to explain problematic maintenance effects in another experimental analysis of SPT. The participant, who demonstrated moderately severe AOS and Broca’s aphasia, received SPT applied sequentially to /p/, /k/, and /ʃ/ in the context of a multiple baseline design across behaviors. The speaker achieved high levels of correct production of /p/ during treatment, which then decreased during /k/ treatment. Similarly, he attained high levels of accuracy of production of /k/ during treatment and then decreased dramatically in productions of /k/ during /ʃ/ training. The error analysis revealed that this speaker overgeneralized productions of the sound currently under treatment to all other sounds under study. Retraining of the previously learned sounds in conjunction with each other returned productions to high levels. Productions were maintained at high levels at 6 weeks following treatment. Anecdotally, varying degrees of overgeneralization had been observed with other speakers who received SPT, but not to the degree observed in the investigation by Wambaugh and colleagues (1999).

The speaker who participated in the preceding investigation is currently participating in another study involving SPT (Wambaugh & Martinez, submitted). He is receiving SPT applied to three groups of three sounds each, with the sounds in each group being treated concurrently. Preliminary findings indicate that overgeneralization appears to be impeded by the multiple sound training. Only minor, transient instances of overgeneralization have been observed to date. A variation of SPT was applied to sound groups with another AOS speaker in an earlier investigation (Wambaugh, West, & Doyle, 1998) and that speaker also demonstrated positive acquisition effects for all trained sounds with minimal overgeneralization. Thus, it appears that treating more than one sound in parallel with SPT may be an effective, and perhaps more efficient, method of sound remediation, for some speakers.

The focus of the preceding investigations was on acquisition and response generalization effects and not on stimulus generalization. Although Wambaugh, Kalinyak-Fliszar, West, and Doyle (1998) measured stimulus generalization to phrases, no efforts were made to promote generalization when it was found to be lacking for two of the three participants. Wambaugh (2000; 2001) examined stimulus generalization effects across several elicitation contexts with two speakers with AOS and aphasia. Multiple baseline designs across behaviors and contexts were used to examine generalization from word and phrase level training to sentence completion, multisyllabic words, and longer utterances. When generalization was found to be lacking in a particular context, treatment was sequentially modified and extended to that context and additional treatment gains were achieved.

Conclusions

Significant progress has been made toward providing objective evidence to support the use of SPT in the treatment of AOS. It is clear that SPT can be expected to result in improved production of target sounds and that training relatively few exemplars of a sound will result in improved productions of untrained exemplars. It appears that significant generalization across sounds is unlikely to occur unless an underlying pattern of errors exists across sounds. Much more research is needed to specify and refine aspects of SPT prior to the consideration of larger scale research. For example, systematic replications should be conducted to examine effects with: (a) patients of differing severities; (b) modifications of the treatment application; (c) extended lengths of maintenance measures; and (d) different stimulus generalization measures. Issues of social validation and levels of outcome measures also require study. Despite the daunting amount of research still required to demonstrate the effectiveness of SPT, clinicians are justified in considering SPT for treatment with patients with moderate
Acquired Apraxia of Speech: Evidence-Based Intervention

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References


Principles of Motor Learning and Treatment for AOS
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In this country, the prevailing view is that apraxia of speech (AOS) represents an impairment in speech motor control. The predominant treatment approaches for AOS focus on affecting the organization of the neuromotor system for relearning of speech motor skills. Relatively few studies investigating treatment efficacy for AOS have been published (Wambaugh & Doyle, 1994). Several researchers in this field, in addressing the paucity of treatment efficacy literature, have suggested appealing to the much deeper literature in the field of limb motor control and learning (e.g., Duffy, 1995; McNeil, Robin, & Schmidt, 1997). Studies of limb motor control have explored the conditions that influence acquisition (i.e., performance during the training session or phase), retention (i.e., maintenance post-training), and transfer (i.e., generalization) of motor skills in the limbs and much of the work has a foundation in the behavioral tradition.

While we typically measure and report acquisition in clinical settings, the findings summarized below demonstrate that acquisition is not necessarily a good indicator of how behaviors will be retained long term (e.g., Schmidt & Bjork, 1992). Schmidt and Lee (1999), in a comprehensive review of the literature in limb motor learning in normal adults, have identified several principles that influence how flexible and skillful control of motoric behaviors is acquired and retained. These principles pertain to (a) the structure and amount of practice provided, (b) the nature and frequency of the feedback that a person receives during practice, and (c) the part-whole relationship between tasks. These principles do not dictate the treatment protocol applied, but rather how the protocol is applied. Below, studies in limb motor learning will be presented and, where available, published applications of these principles to neurological impairments of limb and speech motor systems will be discussed.

Principles of Practice Structure

Principles of practice structure address (a) the order of trials within a practice session (i.e., random or blocked order), and (b) the amount of practice required for learning (i.e., high or low number of trials).

Order of trials during practice: In blocked practice, all trials for a given task are grouped together within a practice session. In random practice, trials on several tasks are presented in random order. The tasks presented may involve different actions or variants of a single action. Schmidt and Bjork (1992) noted that practicing tasks in random order introduces difficulty, or “high contextual interference” (Battig, 1979), to the practice session as it prevents one from developing a stable set for a task. In effect, it requires greater attention, forces retrieval and organization of a different response on every trial, and results in increased processing of the relationships governing variations of a given task. Thus, the random context may more closely simulate a natural context and so result in better retention, and also transfer to novel contexts.

Several studies have demonstrated that random practice order facilitates long-term learning (e.g., Goode & Magill, 1986; Shea & Morgan, 1979). Shea and Morgan had subjects practice three similar arm movement tasks. One group practiced these in random order and the other group in blocked order. The group that underwent random practice demonstrated greater retention at 10 days post-training and more positive transfer. This effect has been repeated for similar task conditions and has been demonstrated for learning timing of movements, perceptual anticipation, control of force, ability to detect movement error, and coordination of bimanual movements (see Schmidt & Lee, 1999, for a review). In summary, blocked practice tends to promote acquisition of the skill during the training period, but random practice leads to greater retention of skill post-treatment and more likelihood of transfer to novel contexts or related tasks.

A small number of studies have examined the generalizability of these findings to individuals with motoric impairments. Hanlon (1996) examined the learning of different functional actions in individuals...
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with a hemiparetic upper limb following cerebrovascular accident (CVA). Random practice resulted in greater retention than blocked practice. Adams and Page (2000) and Knock, Ballard, Robin, and Schmidt (2000) have extended this to the speech motor system. Adams and Page trained 40 adults (20-41 yrs) who did not have AOS to produce an utterance at a slowed rate of speech. All subjects reached a similar level of skill during the acquisition phase, but retention scores were higher when multiple tasks were presented and behaviors were practiced in random order. Knock and colleagues used a phonetic placement approach (e.g., Van Riper & Irwin, 1958) with two individuals with acquired apraxia of speech to compare random and blocked practice orders. They trained simple consonant-vowel (CV) syllables or CVC words. Most speech targets were acquired at a similar rate under both conditions. However, retention at 4 weeks post-treatment was higher for the behaviors trained in random order. The participants did not transfer the effects of treatment to novel speech behaviors. One individual demonstrated generalization to a novel context, and this was best maintained for the behaviors practiced in random order.

**Number of trials during practice:** In the motor learning literature, high amounts of practice often refer to 50 or more repetitions of a given action per training session. Learning is clearly facilitated by a high number of practice trials. This has been reiterated in a series of recent studies in the physical therapy literature examining constraint-induced therapy and intensive practice (Kunkel et al., 1999; Liepert, Bauder, Miltner, Taub, & Weiller, 2000; Miltner, Bauder, Sommer, Dettmers, & Taub, 1999; Taub et al., 1993). Here, individuals with a hemiparetic limb subsequent to CVA undergo 6 to 8 hours of therapy a day for a 2-week period. Therapy involves constraining the intact limb so that the individual is forced to use only the impaired limb. Improvements in function have been far greater than when receiving the same total time of therapy spread over sessions of 15 minutes a day. However, the relative contributions of the intensive practice versus the constraint procedure have not been well differentiated. One study has adapted intensive constraint-induced therapy to language therapy for aphasia with similar findings (Pulvermüller et al., 2001).

Importantly, the studies above provided intensive practice but presented a range of tasks over each day. Shea and Kohl (1990) observed that high numbers of practice trials may interact with others principles of motor learning. They trained individuals to generate specific levels of force. One group received “constant” practice at a single “criterion” force level (100 trials). A second group received “varied” practice where they practiced the criterion task (100 trials) and force levels surrounding the criterion (100 trials each). A third group received constant practice but produced the same total number of trials as the varied group. Acquisition performance was lowest and retention highest for the variable practice group. The criterion group receiving the higher number of trials performed with the highest accuracy during practice, but demonstrated poorest retention. In the context of practice on a single task, or task level, it is possible to provide too many trials so that long-term learning is degraded.

**Principles of Feedback Structure**

Another group of principles that influence motor learning relates to the type, amount, and timing of feedback during practice.

**Type of feedback:** Schmidt and Lee (1999) discuss two primary types of feedback: knowledge of performance (KP) and knowledge of results (KR). KP feedback provides information about how an action is performed (e.g., “Bring your tongue further forward”), while KR feedback merely indicates whether or not a response is acceptable. KP can be provided in the form of verbal comments or visual feedback on kinematics (i.e., position, timing, velocity, and coordination) or kinetics (i.e., force) of movement through instrumentation. Kinematic feedback is frequently used to reveal characteristics of a movement that the individual is unable to perceive unaided, in which case it can facilitate learning. However, when the goal of the task is clear, kinematic KP feedback may provide no additional benefit over the instructor simply providing KR (Swinnen, Walter, Lee, & Serrien, 1993). Kinetic feedback has been used in sports to train sprinters to minimize starting times in races, for example. Broker, Gregor, and Schmidt (1993) demonstrated that this form of feedback can have long-lasting effects on skill level.

In treatments for AOS, the influence of kinematic feedback has been tested using electropalatography.
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(Howard & Varley, 1995), and electromagnetic articulography (EMA; Katz, Bharadwaj, & Carsten, 1999). Katz and colleagues presented a treatment study with a 63-year-old individual with Broca’s aphasia and AOS. They used EMA to provide visual feedback on tongue tip position during silent articulator movement, movement during humming, a nonword task, and a real word task designed to improve placement for /s/ and /f/. Five treatment sessions were provided. Improvements were observed for trained behaviors, but were greater for the nonspeech and nonword than the speech task. Retention examined 10 weeks post-treatment was difficult to interpret. Providing kinematic feedback to individuals with AOS has intuitive appeal and further research is well-justified. Use of kinetic feedback has received more attention in dysarthria and dysphagia treatments (e.g., Dworkin, 1991; Stierwalt & Robin, 1996) than in AOS.

Schmidt and Lee (1999) argue that KP feedback is beneficial to performance during practice, but is most beneficial to retention when the information provided is not obtainable from other inherent sources. It has also been suggested that KP is most useful in the early stages of training, but KR should become the predominant type of feedback to encourage accurate self-evaluation of performance and independence in performance of actions. The use of KR feedback, which has received a good deal of attention, clearly is important in the learning process. Some aspects that have been studied include the frequency and the timing of KR feedback.

**Frequency of KR feedback:** Schmidt and colleagues have performed a series of studies investigating the effect of KR feedback frequency (see Schmidt & Lee, 1999, for a review). When the number of trials was held constant and the ultimate goal was to produce the actions without KR, high frequency feedback (i.e., on 100% of trials) resulted in more rapid acquisition, but poorer retention of trained limb motor behaviors than low frequency feedback (i.e., 30-60% of trials; e.g., Wulf, Schmidt, & Deube, 1993). In the normal speech motor system, Adams and Page (2000) have also reported greater retention when feedback is presented at a low frequency. Schmidt and colleagues (Salmoni, Schmidt, & Walter, 1984; Schmidt, 1991; Schmidt & Bjork, 1992) argued that higher feedback frequency, particularly during later stages of acquisition, may interfere with self-evaluation processes and encourage dependence on external sources of feedback. Consequently, treatment effects will not transfer to the more naturalistic no-KR condition typically used in retention tests. It may also over-shape a behavior resulting in artificially reduced variability and thus loss of flexibility with contextual changes. Low frequency feedback guides an individual’s understanding of acceptable versus unacceptable responses while also developing independence (Schmidt & Lee, 1999).

**Timing of KR feedback:** Schmidt and Lee (1999) argued that a brief delay of 3-4 seconds between an individual’s response and the provision of KR feedback, and between feedback and presentation of the next stimulus, facilitates both acquisition and retention of trained limb actions. When feedback is provided immediately, it may interfere with self-evaluation. Once feedback on a response is provided, a brief delay allows an individual to analyze the previous movement, compare this with the received feedback, and then

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Table 1. Influence of select principles of motor learning on acquisition and retention of limb motor skills.

<table>
<thead>
<tr>
<th>Principles that Facilitate Acquisiton</th>
<th>Principles that Facilitate Long-Term Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure of Practice</strong></td>
<td></td>
</tr>
<tr>
<td>Order of trials</td>
<td>Blocked order</td>
</tr>
<tr>
<td>Number of trials</td>
<td>High (≥ 50)</td>
</tr>
<tr>
<td></td>
<td>Random order¹</td>
</tr>
<tr>
<td></td>
<td>High (≥ 50)¹</td>
</tr>
<tr>
<td><strong>Structure of KR Feedback</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency of feedback</td>
<td>High frequency</td>
</tr>
<tr>
<td></td>
<td>(100% of trials)</td>
</tr>
<tr>
<td></td>
<td>Low frequency¹</td>
</tr>
<tr>
<td></td>
<td>(30-60% of trials)</td>
</tr>
<tr>
<td>Timing of feedback</td>
<td>Delayed 3-4 sec</td>
</tr>
<tr>
<td></td>
<td>Delayed 3-4 sec</td>
</tr>
</tbody>
</table>

¹Similar effects reported in a study/studies of speech motor learning.
²KR refers to knowledge of results.
plan the next movement (e.g., Swinnen, Schmidt, Nicholson, & Shapiro, 1990; also see Salmoni et al., 1984, for a review).

**Transfer Between Part and Whole Task Components**

Another category of principles addresses the part-whole relationship between tasks. It is the tendency in speech therapy, and other fields of motor learning, to work on less complex tasks that are easily stimulable, prior to targeting more complex tasks (e.g., Dworkin, 1991, Nuffield Centre Dyspraxia Programme, 1985). The easier tasks may be referred to as “lead-up activities” (Schmidt & Lee, 1999), and it is assumed that these represent a part of the whole, more complex, task. Schmidt and Lee noted that the action in the lead-up task may be altered when performed in the context of the more complex whole action, and so minimal or no transfer may occur. This general hypothesis is supported by work in another field of study—treatment of linguistically-based communication disorders (syntax, Ballard & Thompson, 1999; Thompson, Ballard, & Shapiro, 1998; semantics, Plaut, 1996, Kiran, 2001; phonology, Gierut, 1998). These reports have demonstrated that training a skill results in transfer to theoretically related skills that are of lesser complexity, but not to related skills of greater complexity or to unrelated skills. In the speech motor system, one could argue that a given movement pattern for a speech skill is more complex than a similar nonspeech movement pattern. Thus, training nonspeech movement patterns should not result in improved motor control for related, but more complex, speech movement patterns. Studies by Katz et al. (1999) and Howard and Varley (1995) with AOS seem to support this proposal. Furthermore, Powell, Elbert, and Dinnnsen (1991) studied childhood phonological disorders and reported that greater transfer to untreated phonological targets is observed when more difficult, or non-stimulable, behaviors are targeted first in treatment, rather than stimulable targets (stimulable here refers to sounds that a child can produce when given an auditory-visual model). While it may seem unintuitive to begin therapy at a more complex level, where the client will experience greater difficulty, research suggests that this promotes transfer.

**Conclusions**

While there is considerable support for using specific principles of motor learning to train novel movement skills in the limbs, the evidence for the speech system is sparse. The few studies available suggest that retention is enhanced by random order of practice (Adams & Page, 2000; Knock et al., 2000), low frequency KR feedback (Adams & Page, 2000), and a high number of trials during each practice session. These conditions may render the learning task more difficult and so acquisition may be less rapid. If clinicians choose to apply principles of motor learning to treatment of AOS, they are cautioned that the effects have been studied primarily in different motor systems and the one study of AOS cited here (Knock et al., 2000) included only two subjects. Currently, there is insufficient data to state confidently that the speech motor system will respond to these principles in a similar way to the limb system.

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**References**


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The relationship between speech abilities and non-speech oral abilities is unclear and has been debated for many years (e.g., Folkins et al., 1995; Weismer, 1997; Weismer & Liss, 1991). Because the same anatomical structures are involved in both speech and non-speech movements, it is not surprising that investigators and clinicians have speculated that there is a relationship between the two. However, studies of normal speakers, as well as individuals with neuromotor speech problems, have yielded inconclusive results.

Describing the nature of the relationship between apraxia of speech (AOS) and non-speech oral abilities is particularly controversial, because there is not universal agreement on the underlying basis for AOS. While most investigators and clinicians consider AOS to be a disorder of speech motor control (Brookshire, 1973; Duffy, 1995; McNeil, Robin, & Schmidt, 1997), others, such as Dogil and Mayer (1998) have proposed that the deficit in AOS is at a linguistic level. If AOS is a linguistic problem, and not a disorder of speech motor control, then treatment of AOS, in theory, should not directly target speech production processes or non-speech oral movements.

Several studies have investigated non-speech oral abilities in AOS (Clark & Robin, 1998; Hageman, Robin, Moon, & Folkins, 1994; Robin, Bean, & Folkins, 1989; McNeil, Weismer, Adams, & Mulligan, 1990). In some of these studies, the subjects with AOS displayed problems with non-speech movements, while in others they did not.

The Evidence

Robin and colleagues (1989) used a strain gauge system attached to the lips to study coordination of the lips and peak articulatory velocity of the lower lip in speakers with AOS. They used speech tasks as well as a non-speech task; however, only peak velocity was measured for the non-speech task. The investigators hypothesized that individuals with AOS might demonstrate lower peak velocities (slower movements) for lower lip movements, perhaps due to a weakness in that musculature. However, they found that the highest peak velocities generated by all of the speakers with apraxia were higher than the highest peak velocity generated by the normal control subject, which did not support their hypothesis.

McNeil and colleagues (1990) were interested in the effect of neurogenic communication disorders on the ability to control the speech apparatus. They compared speakers with AOS to three other groups of subjects: individuals with conduction aphasia, individuals with ataxic dysarthria, and a group of normal controls. Based on both the normative data on speech motor control and on the typical clinical assessments of non-speech oral competencies, they chose to study the ability of the subjects to exert fine force as well as the ability to find and hold a static position with the following articulators: the upper and lower lips, the tongue, and the jaw. McNeil and colleagues found that participants with AOS demonstrated significantly greater instability in orofacial isometric force and static position than did their normal subjects. However, their participants with dysarthria also displayed similar instability, and the data from their participants with conduction aphasia were equivocal. Therefore, these measures did not clearly differentiate the three diagnostic groups.

Hageman and colleagues (1994) compared individuals with AOS to normal speakers on the performance of predictable and non-predictable oral motor tracking tasks. The articulators that they investigated were the lower lip, jaw, and the larynx (i.e., fundamental frequency of sustained phonation). The predictable targets were sinusoidal waveforms with frequencies of 0.3, 0.6, and 0.9 Hz, while the non-predictable target was a complex waveform composed of 10 frequencies of equal amplitude. The 10 frequencies ranged from 0.1 to 1.0 Hz in 0.1 Hz steps. These investigators found that the subjects with AOS performed similarly to the normals on the unpredictable tracking task; however, they performed more poorly than the normals on the predictable tasks. In particular, the movements of the subjects with AOS tended to lag behind the target on the predictable tasks. Hageman
and colleagues proposed three possible interpretations for these results: (a) individuals with AOS are unable to develop a motor plan; (b) individuals with AOS are able to develop a plan, but the plan is poorly defined or inaccurate; and (c) a plan is developed, but the individual with AOS is unable to access that plan. However, the authors acknowledge that: “It is apparent from these data that there are no easy answers to help us understand the mechanisms underlying apraxia of speech” (p. 227).

Clark and Robin (1998) found that individuals with AOS demonstrated variability in certain aspects of motor programming, in particular generalized motor programs (GMPs) and parameterization of those programs. A GMP is a “fundamental movement pattern” (Wulf & Schmidt, 1996) that underlies a variety of different motor behaviors. Parameterization is used to tailor the GMP for a particular action, for example, through the timing or the amplitude of the movement. Using non-speech tasks, Clark and Robin found that 2 of their 4 subjects with AOS demonstrated poor parameterization accuracy and unimpaired generalized motor program (GMP) accuracy, while the other two demonstrated the opposite pattern: good parameterization, but impaired GMP accuracy. However, the investigators also studied individuals with conduction aphasia (CA), and some of these subjects also demonstrated some difficulties with parameterization, although they displayed generally accurate GMPs. The authors suggested that their results may be evidence for different subtypes of AOS. That is, one subtype may have difficulty in developing or executing a GMP while another subtype may have intact GMPs, but may be unable to accurately parameterize those GMPs.

Summary

In summary, a relationship between non-speech oral abilities and AOS has not been demonstrated consistently. While some studies have found speakers with AOS to have an impairment of non-speech oral abilities, others found no difference between their normal subjects and those with AOS on non-speech measures. In addition, there was often no clear differentiation between different neurogenic communication disorder populations on these behaviors. For example, McNeill and colleagues’ (1990) subjects with ataxic dysarthria displayed fine force and isometric position instability similar to their subjects with AOS. In Clark and Robin’s study (1998), 2 of the participants with conduction aphasia demonstrated a pattern of impairment that was similar to 2 of the subjects with AOS (i.e., accurate GMPs, but problems in parameterization). As a result, no non-speech oral impairments have been identified that definitively characterize this disorder. More importantly, there is very little information regarding the relationship between impaired non-speech oral skills and the speech impairment of AOS. Clark and Robin, for example, noted the need for additional studies that would investigate parameterization accuracy and the intactness of GMPs for both speech and non-speech tasks.

So what are the implications of these findings for the treatment of AOS? Regarding AOS treatment, Brookshire (1973) stated: “we see a concern for administering treatment which is directed toward the patient’s ‘key’ areas of deficit and not to ancillary areas…” (p. 192-193). It is obvious that we need further evidence regarding which non-speech oral movement deficits in AOS are key. Importantly, we have been unable to locate any published studies on the use of non-speech oral training for AOS. However, despite the lack of data to support such an approach, perusal of some of the publications targeted toward speech-language pathologists reveals that several individuals are offering workshops on oral motor therapy, and adults with AOS are included in the list of individuals who might benefit from this treatment. In addition, there are books and therapy materials in print that describe the use of non-speech oral motor training for AOS. This training includes tasks such as passive movement of the patient’s articulators by the clinician, sensory stimulation of the articulators, and the repeated production of various non-speech movements such as tongue protrusion and lip retraction.

Given the constraints on the number of treatment sessions imposed by many third-party payers, it is critical that clinicians make optimal use of therapy time. In light of the data that are currently available, it seems premature for clinicians to use clinical time to treat non-speech oral behaviors in the absence of efficacy data when there are treatment studies documenting the effectiveness of various approaches which use speech tasks (e.g., see other papers in this issue). Future
investigations should continue to explore non-speech oral behaviors and their relationship to speech in order to determine which of these behaviors are key factors in the underlying basis for AOS. Once these behaviors are identified, investigations should be designed to explore treatments that will improve the communicative effectiveness of individuals with AOS.

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References


Treatment Research on Augmentative and Alternative Communication for Adults With Apraxia of Speech

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The typical constellation of symptoms among individuals with apraxia of speech (AOS) makes them excellent candidates for augmentative and alternative communication (AAC). When present in relative isolation, AOS is a modality-specific disorder disrupting speech motor programming, sparing communication through other language modalities. Even when AOS is concomitant with aphasia, as is typically the case, many of the affected individuals have only mild to moderate impairments of auditory comprehension, reading, and writing, thus enabling these modalities to augment spoken communication. Unfortunately, there is a paucity of research in the application of AAC with this population. The neglect of this area is regrettable because most individuals with moderate to severe AOS may have the communication and cognitive competencies to allow them to use AAC to communicate more effectively than with their impaired speech. While there is insufficient evidence to confirm this proposal, the likelihood of its veracity mandates that AAC be considered a central component of clinical practice with this population.

This article is intended to review the extant research on the use of AAC among individuals with AOS, to present a rationale concerning why AAC should be a central component of clinical practice with this population, and, lastly, to make suggestions regarding methods that, if applied, would greatly enhance the value of future research regarding the effectiveness and social validity of using AAC approaches with individuals with AOS. Accordingly, this article is intended to encourage clinicians to provide AAC options to their patients with AOS and to increase the awareness of the research community concerning the need to investigate the effectiveness and social validity of AAC approaches for individuals with AOS.

The Four Es

Research regarding the benefits of treatment may concern the efficacy, effectiveness, effects (or outcome), and/or efficiency of interventions (Kendall & Norton-Ford, 1982). As discussed by Robey (2001), these four terms are important to differentiate when considering the contribution of specific studies to the treatment research literature. Accordingly, a brief review is provided because an important conclusion of this literature review is that studies providing direct evidence of the benefits of AAC for individuals with AOS are almost entirely lacking.

Efficacy and effectiveness both refer to the demonstration of behavioral changes as a direct result of treatment. The term efficacy indicates the possibility of a treatment’s benefit to individuals in a defined population when the treatment is applied under ideal conditions, whereas effectiveness refers to possible benefits when the treatment is applied under average conditions, such as during typical service delivery conditions. Efficiency refers to the demonstration of comparative effectiveness of two or more interventions and typically entails a comparison of two treatments in terms of time or number of sessions required to meet criterion, number of trials, treatment cost, or effort (Schlosser, 1999). Treatment effects or outcomes refer to the demonstration of behavioral changes over the time period associated with the application of a treatment, though they may not be directly caused by the treatment. For example, treatment outcome studies may demonstrate treatment effects by comparing pre- and post-treatment measures, but, unlike studies designed to demonstrate efficacy or effectiveness, they do not include probe measures that sample target behaviors repeatedly throughout the course of treatment. Accordingly, treatment outcome studies do not control for the potential contribution of extraneous factors that can affect the results and subsequently confound internal validity. Thus, outcome research designs, such as case studies, do not provide direct evidence for the efficacy, effectiveness, or efficiency of a treatment. Rather they simply indicate that changes have or have not occurred between two points in time. Case studies do offer important data, especially in the early phases of collecting information about treatment
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effects (Robey & Schultz, 1998). The strength of the inferences that can be drawn from a treatment study depends on the level of experimental control, the degree to which the participants and treatment methods are adequately described, and the ways in which the consequences of treatment are measured (Chambless & Hollon, 1998 as cited by ANCDS ad hoc Practice Guidelines Coordinating Committee, 2001). For example, studies that include periodic measurement during the treatment phase and include measures of maintenance and generalization offer stronger evidence than those that evaluate the consequences of treatment based solely upon the participant’s end-of-treatment performance on the set of trained items. Lastly, studies that also obtain information concerning patient and/or caregiver satisfaction with the treatment in terms of its influence on the participant’s quality of life contribute an important dimension to treatment research.

Social Validity

The nature of the evidence provided by treatment research is not exhaustively described by the four Es. The perceived value of changes achieved through treatment is another important variable to consider (Kazdin, 1977). The social validity of a treatment concerns both a social perspective (members of society) and a personal perspective (patients, family, caregivers). To evaluate the social validity of an intervention, ideally both the individuals with AOS and those with whom they communicate would provide feedback concerning whether they value the changes that have occurred. The communication skills selected for intervention and the effect on communication must be valued by the individuals with the communication disorder as well as those with whom they communicate and must be viewed as beneficial to the goal of interacting more effectively with others (Calculator, 1988).

Apraxia of Speech

One of the phrases frequently used in defining the four Es is “individuals in a defined population.” This phrase points to one of the most persistent obstacles in evaluating the AOS treatment literature. None of the studies cited in Table 1 (on page 30) provide specific information concerning how the determination of AOS was made nor even a definition of AOS as the basis for making the clinical diagnosis. In fact, articles were selected to be included in Table 1 on the basis of a very broad set of inclusionary criteria that included any of the following descriptors: Broca’s aphasia, non-fluent aphasia, agrammatic speech, verbal apraxia, apraxia of speech, telegraphic speech, repeated attempts to produce target words, groping and frequent or predominant production of phonemic paraphasias. No exclusionary criteria were used. Clearly, some of these descriptors could equally apply to individuals with Transcortical Motor aphasia (without AOS), to Broca’s aphasia (without AOS), or to Conduction aphasia (without AOS). However, it was deemed necessary to cast a wide net for this preliminary analysis of the AAC/AOS literature despite the fact that the validity of the inferences that can be drawn are certainly compromised by the lack of nosologic specificity. To enable generalization and application of treatment research to “individuals in a defined population,” it is necessary to define and describe the research participants with a fair amount of precision and detail. Research pertaining to AOS has always suffered from a lack of generally accepted diagnostic criteria, and this continues to be one of the most significant methodological issues impeding treatment research in this area.

Because the population of individuals with AOS is heterogeneous, in addition to reporting the diagnostic criteria, it is also important that researchers describe the participants’ strengths and additional impairments. For example, it would be very important to report the presence of non-linguistic sequelae such as limb apraxia, hemiparesis, visual field cuts, initiation difficulties, and reduced cognitive flexibility. Because AAC involves using multiple modalities to communicate, impairments that can affect pointing, gesturing, pantomiming, carrying devices, and using the visual modality for reading, writing, and drawing would greatly influence both the choice of AAC options and the outcome of intervention. Individuals with initiation difficulties and reduced cognitive flexibility present particular challenges as often they do not exhibit generalization and require much prompting to use and switch among different AAC options. Almost all individuals with AOS have a concomitant aphasia. Accordingly, their ability to read, write, and comprehend spoken language are typically impaired, however, often to a lesser degree.
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than their ability to speak. Thus, while AOS is a modality-specific disorder, ostensibly disrupting the stages of speech production from phonetic encoding through motor programming, individuals with this disorder can exhibit an array of other problems (McNeil, Robin, & Schmidt, 1997; Rogers & Storkel, 1999; Wertz, LaPointe, & Rosenbek, 1984).

Augmentative and Alternative Communication

In the introductory chapter of Beukelman and Mirenda’s (1998) seminal book on AAC, they provide three quotes that define communication, AAC, and the population that may benefit from AAC. These quotes are presented below to provide a definitional basis for using these concepts. The first quote is from the National Joint Committee for the Communicative Needs of Persons with Severe Disabilities (1992) and defines communication as:

Any act by which one person gives to or receives from another person information about that person’s needs, desires, perceptions, knowledge, or affective states. Communication may be intentional or unintentional, may involve conventional or unconventional signals, may take linguistic or nonlinguistic forms, may occur through spoken or other modes. (p. 2)

The second quote is from ASHA (1989) and defines AAC as:

An area of clinical practice that attempts to compensate (either temporarily or permanently) for the impairment and disability patterns of individuals with severe expressive communication disorders (i.e., the severely speech-language and writing impaired). (p. 107)

It is important to emphasize that AAC involves “other modes” of communication (Beukelman & Mirenda, 1998), should always be multimodal in nature, and should utilize “the individual’s full communication capabilities, including any residual speech or vocalizations, gestures, signs, and aided communication” (ASHA, 1991, p. 10).

The third quote is also from ASHA (1991) and specifies the population of individuals that may benefit from AAC.

Individuals with severe communication disorders are those who may benefit from AAC—those for whom gestural, speech, and/or written communication is temporarily or permanently inadequate to meet all of their communication needs. For those individuals, hearing impairment is not the primary cause for the communication impairment. Although some individuals may be able to produce a limited amount of speech, it is inadequate to meet their varied communication needs. (p. 10)

Individuals with AOS have great potential to benefit from AAC as their speech impairment is typically moderate to severe and inadequate to meet their communication needs. The degree to which individuals have concomitant impairments disrupting their ability to use language in other modalities will affect the utility of some AAC options, but should not preclude these individuals from using AAC altogether. The presumed interaction among such factors as the user’s impairment profile, communication needs, personality and affective state, the availability of caregiver support for communication, and the type of AAC intervention is important to consider when designing treatment studies and planning intervention.

Comprehensive Communicators

Given the heterogeneity of the population of individuals with AOS, different intervention approaches will be required to meet their needs and to accommodate the unique array of strengths and impairments of each individual. Despite the heterogeneity, many individuals with AOS can use orthographic displays of single words and even short phrases. Many can make good use of gesture and pantomime. Often these individuals can either point to or write the initial segments of words that they cannot produce verbally. Many also have the cognitive capabilities to allow use of complex systems, such as computer-based communication devices. Communication notebooks requiring the ability to locate items by category and/or alphabetically are often the cornerstone of AAC approaches with these individuals. Based on the classification scheme developed by Garrett and Beukelman (1992) for individuals with severe aphasia, the majority of individuals with AOS would be classified as comprehensive communicators. Comprehensive communicators retain a variety of communication skills, such as the ones just listed. They want to communicate with more than one partner and in more than one setting. They initiate interaction and demonstrate some pragmatic competence in discourse (Garrett & Beukelman,
Table 1. *Publications concerning the application of augmentative and alternative communication to individuals with probable apraxia of speech.*

<table>
<thead>
<tr>
<th>Citation</th>
<th>Treatment</th>
<th>Design</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skelly, Schinsky, Smith, &amp; Fust, 1974</td>
<td>paired Amer-Ind training with speech</td>
<td>case study [effects] (n=3)</td>
<td>Amer-Ind gestures facilitate speech production</td>
</tr>
<tr>
<td>Rabidoux, Florance, &amp; McCauslin, 1980</td>
<td>Handi Voice</td>
<td>case study [effects] (n=1)</td>
<td>aided communication facilitates communication success</td>
</tr>
<tr>
<td>Dowden, Marshall, &amp; Tompkins, 1981</td>
<td>Amer-Ind training</td>
<td>case study [effects] (n=2)</td>
<td>gestures may be acquired; may facilitate speech; gestures as AAC may improve functional communication</td>
</tr>
<tr>
<td>Lane &amp; Samples, 1981</td>
<td>Blissymbol training</td>
<td>case study [effects] (n=4)</td>
<td>individuals with less severe aphasia learned better than individuals with more severe aphasia</td>
</tr>
<tr>
<td>Kearns, Simmons, &amp; Sisterhen, 1982</td>
<td>Amer-Ind training vs Amer-Ind training paired with speech training</td>
<td>Multiple baseline Across behaviors [efficacy] (n=1)</td>
<td>Unimodal training results in acquisition and maintain-ence of Amer-Ind gestures, but facilitation of verbal responses resulted only with extensive multimodality training</td>
</tr>
<tr>
<td>Coelho &amp; Duffy, 1985</td>
<td>manual sign training</td>
<td>case study [effects] (n=1)</td>
<td>successful acquisition of signs, but not used by participant in his interactions at home</td>
</tr>
<tr>
<td>Beukelman, Yorkston, &amp; Dowden, 1985</td>
<td>multiple communication systems: multimodality communication, notebooks to augment auditory comprehension and expression; voice output communication aid</td>
<td>case study [effects] (n=1)</td>
<td>AAC applied with communication needs assessment continually monitored throughout intervention proved successful in facilitating return to work</td>
</tr>
<tr>
<td>Garrett, Beukelman, &amp; Low-Morrow, 1989</td>
<td>multiple communication systems: speech, writing, drawing, word dictionary topically organized, alphabet card, printed conversational control phrases</td>
<td>case study [effects] (n=1)</td>
<td>training multiple systems and identification of most efficient system in context resulted in improved conversational initiation, increased conversational turns and fewer communication breakdowns</td>
</tr>
<tr>
<td>Bailleire, Georges, &amp; Thompson, 1991</td>
<td>communication notebook training</td>
<td>single-subject multiple baseline design [effectiveness] (n=2)</td>
<td>post-treatment, participants able to request basic items and communicate personal information, generalization required extensive time and message-specific training in target context</td>
</tr>
<tr>
<td>Yanak &amp; Light, 1991</td>
<td>Amer-Ind, word board, and communication notebook training</td>
<td>case study [effects] (n=1)</td>
<td>participant learned to communicate by pointing to stored messages and generalized to actual social situations</td>
</tr>
<tr>
<td>King &amp; Hux, 1995</td>
<td>intervention using Talking Word Processing Software</td>
<td>case study [effects] (n=1)</td>
<td>spoken computer output enhanced independent written language skills</td>
</tr>
</tbody>
</table>

AOS = apraxia of speech
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1998). AAC interventions for comprehensive communicators are complex in that these individuals can use a wide variety of techniques such as communication notebooks, limited natural speech, gestures, alphabet cards, writing, drawing, maps and other schemata, customized or electronic word dictionaries, and electronic communication devices with voice output. Training on all useable techniques is warranted. Furthermore, a critical aspect of AAC intervention for comprehensive communicators is the need for guided practice concerning when to use which technique and to learn to switch modalities or techniques based on the situation or when a communication breakdown is encountered (Garrett & Beukelman, 1998). Training also needs to occur in natural communication contexts with a variety of partners to facilitate generalization. As Garrett and Beukelman (1998) indicate, failure to teach and train in naturalistic situations is one of the most common reasons comprehensive communicators fail to use their AAC systems effectively.

**Intervention Studies**

Table 1 displays a list of studies that concern the application of AAC to individuals with AOS based on the set of descriptors mentioned above. The list contains 12 peer-reviewed articles mostly published in two journals: *Augmentative and Alternative Communication* and *Aphasiology* (also *Clinical Aphasiology* or *Proceedings of the Clinical Aphasiology Conference*). There are five studies that included communication boards or notebooks as a key component of intervention (Bailey, 1983; Bellaire, Georges, & Thompson, 1991; Beukelman, Yorkston, & Dowden, 1985; Garrett, Beukelman, & Low-Morrow, 1989; Yanak & Light, 1991). There are five studies that report training of manual gestural systems: manual sign (Coelho & Duffy, 1985) and Amer-Ind (Dowden, Marshall, & Tompkins, 1981; Kearns, Simmons, & Sisterhen, 1982; Skelly, Schinsky, Smith, & Fust, 1974; Yanak & Light, 1991). Two articles report training voice output communication aids (Beukelman et al., 1985; Rabidoux, Florance, & McCauslin, 1980).

While none of the 12 studies directly address efficiency, all of them make reference to the extensive training and in some cases, assessment procedures, required to incur acquisition and/or generalization of the AAC method. For example, the study by Bellaire and colleagues (1991) used a single-subject multiple baseline design to investigate the use of picture communication boards by two individuals with severe Broca’s aphasia. Their investigation demonstrated that training resulted in both participants being able to use the board for making requests (e.g., coffee and cookies) and personal responses (e.g., name and prior occupation), but that generalization outside of the treatment room required extensive training (greater than 23 sessions). Furthermore, attempts to promote generalization using role-playing techniques in the treatment room did not result in the participants spontaneously using the communication board during coffee hour at the nursing home (the context chosen to assess generalization). Generalization training had to occur in the natural settings in which the users would communicate. Training during coffee hour involved providing verbal cues to use the board, modeling use of the board, and physical assists when necessary. Neither participant exhibited response generalization to untrained items, but both demonstrated successful acquisition and maintenance of trained items representing various objects and actions. This study also indicated that training and generalization of social responses may be more complicated than training communication for the purposes of transaction, such as requesting specific information or objects.

All but two of the studies, Bellaire and colleagues (1991) and Kearns and colleagues (1982), consist of comprehensive case reports. Thus, most of the relevant literature provides information concerning treatment effects and lacks the experimental control necessary to provide stronger evidence of treatment efficacy or effectiveness. Nonetheless, all of these case studies provide detailed descriptions of the participants’ communication needs and abilities upon which assessment, AAC development, and training strategies were based and offer a rich foundation for future research. These pioneering reports are exceedingly useful for dissemination of information concerning clinical decision-making and for generating testable hypotheses concerning AAC intervention with individuals with AOS. However, without experimental control, the impact of these studies is limited.

The study by Yanak and Light (1992) is an example of a case study that provides detailed de-
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Acquisitions of the participant’s communication needs and abilities upon which assessment, AAC development, and training strategies were based. The 38-year-old individual described in this study had suffered a cerebrovascular accident 18 months prior to the onset of the intervention program. He exhibited severe expressive deficits with mild auditory and reading comprehension deficits and limited ability to write primarily due to word-finding difficulties. He desired to be able to communicate with unfamiliar partners, to live independently, and to achieve his goal of reemployment. The intervention program consisted of client-based individual sessions designed to teach AAC techniques (Amer-Ind, word board and communication notebook use) and community-based activities designed to facilitate use and generalization of these techniques. The authors describe the process of vocabulary selection for the communication notebook as entailing the analysis of the demands and opportunities in specific environments (ecological inventories) allowing the user to either validate or discard vocabulary items suggested by the clinician (Sigafoos & York, 1991). Three types of activities were described to facilitate interactions: group sessions with two other clients, simulations of community interactions role-played by the clinician, and actual community-based interactions with a variety of unfamiliar partners that was initiated 7 weeks into the 12-week program. During the group sessions that continued throughout the intervention program, the client was expected to present problems encountered in daily living and propose solutions to be considered by the group. Modification of the communication notebook was incorporated as an ongoing process. This study provides useful information concerning the integration of simulation and interactions outside the clinical setting, as a means of both guiding vocabulary selection and promoting generalization. One component that the authors concluded would have improved the outcome of the study was if they had incorporated partner or “facilitator” training. The client’s family tended to “pre-empt” (Calculator, 1988) or dominate the conversational interactions, thereby limiting the amount of time and opportunities the client had to formulate his messages.

Several of the studies indirectly address the social validity of the AAC intervention. For example, the participant in Bailey’s (1983) study of Blissymbol training requested that the symbols be removed from his communication board and indicated a preference for the single word vocabulary. While an indirect measure of social validity, this case report indicates that the user did not value the Blissymbols. The participant in the Coelho and Duffy (1985) study demonstrated good acquisition of the manual signs but did not use them at home. It is difficult to know whether this was due to inadequate generalization training, an inability to use the signs without prompting, or because the user did not value the communication approach. The uncertainty regarding why generalization does not always or easily occur underscores the need for direct measures of social validity to determine whether user dissatisfaction is a contributing factor. The primary dependent variable in treatment research is typically the target behavior that is to be changed by the intervention (e.g., acquisition of an AAC system, increased use of AAC in requesting or commenting, increased initiation or number of conversational turns with AAC use). It is perhaps equally as important to determine whether participants value the consequences of the intervention. Accordingly, social validity measures ought to be included as a dependent variable in treatment research, because the perceived value of an intervention cannot necessarily be inferred from other outcome measures.

Summary

The following statements summarize the information that can be gleaned from these 12 studies concerning AAC intervention for individuals with AOS:

1. Many of the participants demonstrated acquisition of the targeted behaviors in controlled settings;
2. Many of the participants exhibited meaningful and substantial improvements with respect to communication over the course of treatment;
3. Extensive training was required, especially for generalization;
4. Studies addressing the role of partner support were conspicuously lacking (but see Garrett & Beukelman, 1995; Kagan, Black, Duchan, Simmons-Mackie, & Square, 2001);
5. Measures of social validity were absent;
6. Acceptance of AAC by participants was not directly addressed by any of the studies, but was recog-
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recognized as an important factor by many of the investigators;

7. The absence of AOS criteria in this body of literature limits the generalizability of the conclusions;

8. The majority of studies only measured treatment outcomes and, without experimental control, offer limited evidence concerning the value of AAC for this population.

In conclusion, the synthesis of these studies indicates future success for the application of AAC to individuals with AOS, but also reveals specific areas where additional research effort is required.

In January 2001, reimbursement for AAC was approved for Medicare recipients, making the acquisition and training of AAC devices more accessible for a larger segment of the population and opening doors for improved utilization of AAC generally. AAC intervention is time and resource intensive and, accordingly, the benefits of these approaches need to be demonstrated. Most of the case studies reviewed indicate that substantial time is required to promote successful use of AAC and necessarily involves the following steps:

1. Conduct assessment of abilities and communication needs;
2. Conduct ecological inventories for vocabulary selection;
3. Train use of the selected tools and strategies;
4. Provide opportunities for simulated and actual community-based interactions using AAC; and
5. Provide facilitator training to family and other communication partners.

While the new Medicare policy of funding AAC devices clearly represents significant progress, without complementary funding for therapy to provide the necessary training, the battle is only half won. Furthermore, without improved treatment research to support the efficacy of AAC practices, continued funding may be at risk. It is imperative that future investigations include experimental control, because without that level of methodological rigor, the scientific contribution is insufficient. For many individuals with AOS, it is likely that AAC offers the greatest potential for independent and wide-ranging communicative interactions. Without question, research in this area is needed given the paucity of extant studies and the clear potential for positive results. More importantly, the opportunity for many individuals with AOS to substantially improve their communicative interactions may be diminished if the potential utility of AAC is not explored in much greater depth with this population.

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References


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