Treatment Guidelines for Acquired Apraxia of Speech: Treatment Descriptions and Recommendations

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This article is the second of two reports from the Academy of Neurologic Communication Disorders and Sciences (ANCDS) Writing Committee of Treatment Guidelines for AOS. The first report provided a review and evaluation of the AOS treatment evidence (Wambaugh, Duffy, McNeil, Robin, & Rogers, 2006a). The current report is focused on the aspects of guidelines development that followed the review of the evidence. The major categories of AOS treatments are described in terms of treatment techniques, targets, outcomes, candidacy, and evidence quality. In addition, this report provides the committee's treatment recommendations and suggestions for future research.

This report is a product of the acquired apraxia of speech (AOS) treatment guidelines project initiated by the Academy of Neurologic Communication Disorders and Sciences (ANCDS). It provides descriptions of AOS treatments along with treatment recommendations derived from the AOS writing committee's review of the AOS treatment literature. A summary and evaluation of that literature was pro-

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vided in a companion article (Wambaugh, Duffy, McNeil, Robin, & Rogers, 2006a). The entire AOS technical report from which this report and the accompanying report were drawn is available on the ANCDS website, along with the AOS evidence table (Wambaugh, Duffy, McNeil, Robin, & Rogers, 2006b).

The development of AOS evidence-based treatment guidelines is part of a broader undertaking by ANCDS in which practice guidelines have been and are currently being generated for specific neurologically impaired patient populations (Frattali et al., 2003; Golper et al., 2001). As described by Fratalli et al., the process of guidelines development requires a systematic and comprehensive review of the pertinent literature accompanied by objective assessment of the strength of the evidence. Then, guideline developers are obligated to "craft guidelines based wholly on the reviews and assessments of levels of scientific evidence" (Fratalli et al., 2003, p. x). Additionally, guidelines development entails dissemination of information to clinicians and delineation of future research needs.

This report addresses the aspects of guidelines development that followed the review of the evidence. It provides descriptions of the treatments reviewed, ratings of the general categories of AOS treatments, treatment recommendations, and suggestions for future research. In the following sections, each general type of treatment will be reviewed in terms of treatment rationales, techniques employed, treatment targets, candidacy for treatment, treatment effects, and level of evidence supporting use of the treatment(s).

AOS TREATMENT APPROACHES

In the review and evaluation of the treatment literature, the AOS writing committee identified the following general categories of AOS treatments:

1. articulatory kinematic,
2. rate and/or rhythm,
3. alternative/augmentative communication (AAC),
4. intersystemic facilitation/reorganization, and
5. other.

Each of the general treatment approaches are reviewed in the following sections. The reviews include a summary of the *rationales* provided for each treatment type along with a description of the *treatment techniques* and *treatment targets*. The outcome measures are described, and a synopsis of the *outcomes* is provided. An overview of the participants in each approach is given and *candidacy issues* discussed. Finally, the evaluations of the *quality of the evidence* for the general approach are summarized.

Articulatory Kinematic Treatments

Rationale

As indicated previously, half of the investigations concerned treatments characterized as articulatory kinematic. In general, it appears these treatments were developed and/or studied based on assumptions consistent with Rosenbek, Lemme, Ahern, Harris, and Wertz's (1973) influential statements that AOS "is a nonlinguistic sensorimotor disorder of articulation .... Therefore, therapy should concentrate on the disordered articulation .... (and) emphasize the regaining of adequate points of articulation and the sequencing of articulatory gestures" (p. 463). The rationales provided by the authors of these reports, as well as the techniques employed, explicitly and/or implicitly indicated that it was important to focus treatment on improving spatial and temporal aspects of speech production.

Techniques

Numerous techniques were utilized across the 30 articulatory kinematic investigations to promote improved speech production (Table 1). One commonality observed across all investigations was motoric practice of speech targets. That is, although most of the approaches employed some form of stimulation, verbal production was requisite. Most of the treatments also relied on the technique of modeling/repetition to elicit productions of the desired speech behavior. A variation of modeling/repetition, "integral stimulation," was also employed in several investigations (e.g., Deal & Florance, 1978; Florance & Deal, 1977; LaPointe, 1984; Rosenbek et al., 1973; Wambaugh, Kalinyak-Fliszar et al., 1998; Wambaugh, West, & Doyle, 1998; Wambaugh, Martinez et al., 1999; Wertz, LaPointe, & Rosenbeck, 1984). Integral stimulation involved instructing the patient to "watch me, listen to me, and say it with me."

Obviously, both modeling/repetition and integral stimulation involve auditory and visual stimulation regarding production of the speech target. Such stimulation requires the patient to infer the articulator movements necessary for correct production. Other stimulation techniques have been utilized that provide direct instruction in terms of movement of the articulators. Articulatory placement

TABLE 1. Articulatory kinematic reports.

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Aten (1986)	voiceless fricatives in CV and CVC words	individual with severe AOS and relatively spared auditory comprehension	treatment failed to re-establish verbal skills and that prolonged periods of speech exercise may not be as effectual as therapy aimed at enhancing the communication skills (as opposed to speech skills) such as AAC	study suggests that severe apraxia may not improve with therapy primarily directed at the speech impairment. Given that the study yielded negative findings, the lack of experimental control is not as problematic as when positive results are claimed
Bose (2001)	short phrases	AOS speaker with impaired/ limited verbal output	careful selection of the utterances could help individuals with severe aphasia-apraxia acquire some functional phrases (even in short-term rehab); positive results for "imperatives" and "active declaratives," but not for "interrogatives"	good multiple baseline study
Cherney (1995)	sentence production	patients with reduced verbal production skills	ORLA may be an effective treatment for persons with AOS and Broca's aphasia	treatment warrants additional study
Corbin (1951)	vowels, consonants, words, sentences	patients with aphasia and or AOS with severely restricted speech production skills	progress observed for all patients in program	weak case reports, with focus more on treatment techniques than results; all gains were reported anecdotally
Dabul (1976)	CV CV syllables	apraxic patients with general sequencing impairments	improved response suggests successful remediation by use of the treatment of a general sequencing impairment	not a convincing study; the dependant variable of improved PICA scores could be for a number of reasons
Deal (1978)	short utterances	severe AOS with ability to follow auditorilly presented instructions and monitor clinician's and their own productions	the modified 8-step continuum was successful in restoring some communication ability, successful home programs were developed, and the complete program was unnecessary for 2/4 patients; modifications in step 4 were developed.	a descriptive study with limited data and no controls; patients proceded through the program successfully but no conclusions can be drawn about efficacy/ effectiveness; an outcome study—at best—because of absent controls historically valuable for helping to lay out a treatment hierarchy for AOS; lent support to the Rosenbek 8-step text continuum

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Florance (1977)	10 target sentences of 3+ words	patients with severely restricted verbal output due to AOS and/or aphasia	treatment resulted in a significant increase in utterance length with no correlation between MLU or communicative success and PICA scores; "effective in establishing volitional communicative ability"	questionable results due to large number of patients in spontaneous recovery period; very large gains made by a few patients who were only a few mpo; measure of volitional speech not provided
Freed (1997)	functional words	severe apraxic-aphasic patient with limited verbal output and PICA profile C/W AOS (OA PICA %ile = 43)	target words and phrases were produced accurately during and after treatment; results show that "PROMPT cuing can be an effective method of facilitating verbal productions" (p. 369)	authors may be correct although data on how often PROMPT cues were necessary would have been helpful (i.e., initial treatment step was simple repetition and that may have been the influential variable or it may have combined with PROMPT to be effective).
Holtzapple (1977)	4 sounds	patient with moderate to severe AOS who has difficulty with production of individual speech sounds	decrease in need for maximum stimulation as treatment progressed; increase in correctly produced sounds at weakest level of elicitation	changes appear to be as described; effects may not have been due to treatment, but to spontaneous recovery or other treatment
Howard (1995)	tongue movement, sounds, sounds in words	individual with severe AOS and oral sensory impairment	approach is valuable as it allows the individual with AOS to control dynamic aspects of articulatory gestures (approach and release phases of consonant production) not just static targets; also, visual feedback using EPG *facilitates* gradual modification of abnormal articulatory activity and provides a means to identify articulatory activity not accessible via auditory perception	this approach may be most justified for patients with oral sensory involvement; this report is lacking so much information, particularly with respect to treatment implementation and the time course of changes that it is impossible to judge the likelihood that this approach *is* useful for individuals with severe AOS

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Kahn (1998)	one syllable real words and one syllable nonwords beginning with /m, l, s, k, g, b/; high levels (90%) of correct production prior to treatment	AOS speaker with sound errors at single word level	treatment resulted in improvements in production of real words only (no changes in nonwords). Interpreted as evidence that the participant had "less access to the nonlexical route of speech production."	lack of experimental controls serves to limit conclusions. No pretreatment speech production data were available. It appears that nonword and real word lists were not equal in terms of difficulty prior to the application of treatment (i.e., based on data from first treatment session). Data from oral reading of nonwords was likely confounded by aphasia.
Katz (1999)	sound productions in nonwords and real words	AOS speaker with consistent articulatory errors	findings suggest that visual position can be used to treat biofeedback concerning tongue-tip nonspeech oral and (to a lesser extent) speech motor behavior in adults with Broca's Aphasia and AOS	good study, however improvements could be seen with more subjects and the investigation of generalization
Knock (2000)	CV and VC syllables and CVC words	patient with severe AOS and difficulty with syllable and simple word production	blocked and random practice resulted in similar rates of acquisition; performance on blocked behaviors was more variable; greater retention at 4 weeks posttreatment for randomized behaviors; no generalization to untrained behaviors	better retention evident for S2 during the training condition, but not clear for S1; S2 failed to show any treatment effects on probes (i.e., not during treatment) with both treatment presentations
LaPointe (1984)	sounds in common words	AOS speaker with moderate number of errors at word level and aphasia less severe than AOS	progress faster and performance reached higher accuracy levels for trained than untrained lists	concur with author's interpretation of results

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Maas (2002)	nonwords beginning with target sound or blend	patients with moderate to severe AOS who experience difficulty with sound production in simple words	no generalization from singletons to clusters, limited generalization from 3-element clusters to singletons and 2-element clusters for one subject	results are not clear cut with respect to generalization; S1—generalization clearly occurred from complex to simple for only the first application of "complex" training and not the second and may have exhibited limited generalization from "simple" training to cluster production for words (but, not nonwords); S2—did not demonstrate generalization from complex to simple (only one data point exceeded baseline levels)
Raymer (2002)	isolation, CV syllables and pairs	patient with severely limited verbal output and difficulty with production of specific sounds	productions of /t/ and /p/ increased to well above baseline levels; /k/ productions remained incorrect; overgeneralization of /t/ and /p/ noted to other sounds; these modest changes were likely due to treatment	treatment probably resulted in sound changes, although lack of change in /k/ was problematic
Rosenbek (1973)	functional utterances	patient with moderate to severe AOS who requires an increased repertoire of utterances	the 8-step continuum can help to restore some communicative functioning to patients with severe AOS; the continuum appears to "represent a legitimate task continuum"	although no experimental control was demonstrated, the patients had chronic AOS; treatment appears to have promise
Sands (1978)	?	less than severe AOS	"therapy with J.P had been effective in improving place and manner productions and in virtually eliminating omission errors"	no conclusions can be drawn about treatment effects; no experimental control was exerted
Simmons (1980)	sentences	premorbid ability to read Braille and a moderate acquired AOS	Braille plus auditory stimulation served as a more powerful stimulus in eliciting verbal responses than auditory stimulation alone	order effects may be a slight confound; however, author replicated the effects by withdrawing Braille twice; conclusion seems warranted

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Simpson (1989)	vocalization, movement	patients with apractic mutism	different rate and degree of recovery for apraxia and aphasia, coupled with the responsiveness of mutism to motor speech initiation/programming techniques supports that a motor speech component is the primary cause of prolonged mutism	no data provided to support efficacy of any treatment techniques; inadequate explanation of treatment techniques provided
Square (1985)	minimal pair words, phrases	patient with moderate to severe AOS with or without aphasia	improvement seen in production of trained phrases and words; improved intelligibility scores	results are unsubstantiated due to brief nature of report
Square (1986) Square-Storer (1989)	minimal pairs, polysyllabic words, phrases	AOS patients with limited verbal output for whom more traditional methods of treatment have failed	PROMPT treatment may be effective for training accurate target verbalizations among chronic apractic-aphasic patients	without experimental control, convincing that PROMPT works for most (not all) targets but no generalization demonstrated
Stevens (1989)	primarily words	AOS patients with verbal output largely limited to stereotypies	treatment resulted in ability to communicate with single words and phrases	lack of support for claims
Stevens (1983)	same as above	severe AOS or "expressive aphasia," including Ss with no verbal output (according to authors)	all Ss showed significant gains in verbal expression and reduction of stereotypic perseverative utterances; "MIPT shows initial promise as a therapy technique for severely, expressively impaired individuals who typically fail or are excluded from traditional therapy approaches"	nothing can be concluded from this report, other than that the authors believe their approach helped some patients who had made few gains prior to MIPT; the few data presented do not even clearly demonstrate "significant" gains or reduction of stereotypic utterances, let alone that they were attributable to the treatment provided
Wambaugh (1996) Wambaugh, Kalinyak-Fliszar (1998)	words—specific problem sounds selected	moderate-severe AOS with relatively intact (re language production) auditory comprehension, and WAB-classified Broca's aphasia	treatment resulted in increased correct sound production for all Ss in trained and untrained words; generally limited stimulus and response generalization; positive maintenance effects but some loss of gains posttreatment; *for sounds that did not reach criterion for acquisition, treatment gains were not maintained	concur with authors' interpretation

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Wambaugh (1999)	same as 1998a	patient with moderate AOS with relatively consistent sound errors	treatment promoted increased correct productions of trained sounds and untrained exemplars of those sounds; sounds currently under treatment incorrectly overgeneralized to previously treated sounds—interfering with maintenance; maintenance training helped to reestablish correct sound productions	concur with authors
Wambaugh, West (1998)	sound groups at the sentence level	moderate AOS with nonfluent aphasia; stimulable for correct production of all sounds	treatment resulted in improved production for all trained sound groups, with response generalization closely following acquisition effects	conclusions appear warranted
Wertz (1998)	sounds in words, vocalization	patient with severe AOS, apraxia of phonation, and aphasia	abdominal presses were unsuccessful in promoting vocalizations; laryngeal manipulation plus verbal coaching was successful in improving voicing for vowel production; imitative drill plus verbal feedback resulted in improved sound productions	author's interpretations are likely correct; however, because control was lost in the multiple baseline design across behaviors during vowel training, spontaneous recovery may have been a factor; control was maintained for sound productions which provides support for claims
Wertz (1984)	not specified	moderately severe stroke-induced AOS with varying degrees of aphasia (PICA 15–75%ile)	patients with AOS improve; type of treatment appears to influence improvement (4/5 patients who did not improve received group treatment with no direct manipulation of the AOS. "our results do not support the efficacy of treatment for patients suffering apraxia of speech, nor do they deny it"; both groups were treated	concur with author's conclusions; results suggest that patients with AOS who receive direct treatment for the AOS recover from the AOS more completely than those who receive general group stimulation with no direct attempt to manipulate speech; but, the study was not designed to assess AOS treatment specifically—the analysis was done post hoc from data in a well-conducted text study of aphasia; the results, therefore, should be considered "circumstantial"

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TABLE 1. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Wertz (1984—text)	variety	Patients with moderate to severe AOS who experience difficulty with sound production in simple words (treatments described for S1–S5); patients with moderate to mild AOS who exhibit some difficulties in sound production (S6–S8)	for most reported cases, effects of treatment were positive; authors qualified findings to take into account spontaneous recovery or home practice; no effects noted for S8	authors interpretations appear to be appropriately cautious; most experiments appear to be basically sound but methodologically sketchy; experimental control was lost in a few experiments because of unstable baselines or generalization across behaviors

cues have been used in numerous investigations to communicate specific information about sound production. Typically, placement cues have been provided for sounds produced in error and have taken the form of drawings (Raymer et al., 2002), videotaped models (Aten, 1986), verbal instructions (Wambaugh et al., 1998a; 1998b, 1999), and visual modeling (Wambaugh et al., 1998a; 1998b; 1999). Placement cues have also been used in conjunction with the related techniques of phonetic derivation and shaping (Knock et al., 2000; Wertz et al., 1984). In such cases, instructions were provided regarding how to modify existing productions to obtain different or more acceptable productions.

Prompts for restructuring oral and muscular phonetic targets (PROMPT; Square, Martin, & Bose, 2001) is perhaps the most sophisticated of the stimulation techniques for providing direct instruction for speech production in the treatment of AOS. PROMPT provides a combination of auditory, visual, tactile, and kinesthetic cues that are "dynamic in nature and are designed to provide sensory input regarding the place of articulatory contact, extent of mandibular opening, presence and manner of articulation, and/or coarticulation" (p. 769) (Bose, Square, Schlosser, & van Lieshout, 2001). These cues are reportedly usually focused on classes of speech movements and can be applied to various levels of speech production (e.g., speech sounds in isolation to sentence level productions). Because of the relative complexity of the cues provided in the application of PROMPT, therapist training appears to be requisite for correct application of the treatment.

Written cues are another form of stimulation that have been used frequently as a supplement to articulatory-kinematic techniques (Cherney, 1995; Deal & Florance, 1978; Florance & Deal, 1977; Rosenbek et al., 1973; Wambaugh et al., 1998a). Provision of the written form of the targeted speech production does not provide articulatory kinematic instruction and may be considered a form of intersystemic facilitation/reorganization (and will be discussed in a subsequent treatment section). However, such written cues are noted in the present treatment section to reiterate the fact that many AOS treatments have utilized a combination of approaches.

Beyond the type of stimulation provided, the type and/or organization of practice is another important treatment component. There appears to be potential benefit in practicing target productions in a contrastive manner with either nontarget productions or other target productions. Wertz et al. (1984) advocated the use of contrastive practice of sounds and provided data from one participant to support use of this technique. They suggested starting with contrasts in which the target sound's environment serves as the contrast (e.g., changing the vowel in CV syllables such as /se/-/si/-/su/). They further recommended moving toward contrasting the target sound with different sounds that gradually become more similar to the target sound. Practice in contrasting the target sound with the sound that most closely approximates the patient's typically replacing sound has also been employed by Wambaugh et al. in their use of minimal contrast practice (Wambaugh et al., 1998a, 1999, 2004). It should be noted, however, that Wambaugh et al. employed other techniques (e.g., integral stimulation, phonetic placement cues, graphic cues), along with minimal contrast practice. Similarly, Howard and Varley (1995) utilized minimal pair words with electropalatographic feedback to practice contrasting tongue contacts. Square et al. (1986) and Square-Storer and Hayden (1989) also utilized minimal pairs during PROMPT treatment and indicated that PROMPT should be utilized to contrast speech movements (Square et al., 2001).

The concepts of random stimulus presentation versus blocked stimulus presentation relate to the use of contrastive practice. In blocked stimulus presentation practice, all trials with one target behavior occur together as a "block." In random stimulus presentation practice, trials of all targeted behaviors are randomly interspersed within a treatment session. For example, if three sounds have been targeted for treatment, blocked stimulus presentation practice would require that one sound be practiced first for X number of trials, followed by practice of each of the remaining sounds separately (e.g., 100 trials of /s/, followed by 100 trials of /p/, followed by 100 trials of /t/). Random stimulus presentation practice would entail practice of all three sounds concurrently, with the order of the stimuli being randomized (e.g., s-p-t-t-s-p-p-s-t, etc.). Literature from the area of limb motor learning suggests that blocked stimulus presentation practice facilitates[1]

[1]The terms *facilitate* and *facilitation* are used to denote the common meanings of "to make easier" or "to bring about" (Merriam-Webster, 2005). They do not carry any meaning relative to duration or level of processing. However, the term *facilitation study* is used to indicate an investigation in which the independent variable was limited in terms of exposure (after Howard, Patterson, Franklin, Orchard-Lisle, & Morton, 1985).

more rapid acquisition of motor behaviors, but random stimulus presentation practice promotes better retention and transfer (see Schmidt and Lee [1999] for a review). Knock et al. (2000) investigated the effects of blocked and random stimulus presentation practice on production of stops and fricatives with two participants with AOS. Although their results did not coincide precisely with the limb motor literature (i.e., no differences in acquisition rates were seen across blocked and random practice), their findings did suggest that random stimulus presentation practice may result in superior retention and transfer.

The preceding techniques relate to the events preceding production of the speech target. Another potentially important factor of treatment is the feedback that is provided following production. Although rarely specified in AOS treatment studies, feedback has most often taken the form of verbal feedback provided by the therapist. Feedback has been discussed as being important from a motor learning perspective in terms of type, schedule, and latency (Knock et al., 2000). That is, feedback regarding accuracy of a response (knowledge of results, KR) and feedback regarding qualitative aspects of a response (knowledge of performance, KP) may differentially impact acquisition, retention, and transfer (Schmidt & Lee, 1999). Additionally, the timing and frequency of the feedback may influence treatment effects (Knock et al., 2000). Some AOS treatments have been designed to utilize a combination of KP and KR (e.g., Knock et al., 2000; Maas et al., 2002; Wambaugh et al., 1998). Others have been structured to provide only KP in the event of incorrect responses (e.g., Bose et al., 2001; Square et al., 1986; Square-Storer & Hayden, 1989). Of course, use of KP implicitly provides KR as does the use of response-contingent hierarchies. Although most articulatory-kinematic treatment investigations did not indicate whether feedback was employed, it may be assumed that feedback likely was utilized in many instances. Recent work by Austermann et al. (2004) (not included in evidence table due to 2003 "cut-off") suggests that the use of delayed feedback (e.g., a delay of 5 seconds as compared with immediate feedback) may promote enhanced retention and transfer of trained speech productions for some individuals with AOS.

KP in the form of biofeedback has received limited study in this area. Electropalatography (EPG) may be used to provide biofeedback regarding the timing and location of tongue contact with the hard palate through the use of a custom-fitted pseudopalate embedded with electrodes. Improvements in articulation were described by Howard and Varley (1995) in a case study with an individual with AOS. Clear effects of EPG treatment for AOS remain to be demonstrated. However, with increasing availability of this technology (e.g., EPG3; Articulate Instruments, 2005; LogoMetrix, 2005) and further research, EPG may be an option for some patients (see comments in evidence table). Electromagnetic Articulography (EMA) has also been utilized to provide biofeedback of tongue-tip movement with an individual with AOS to improve /s/-/S/ contrasts (Katz et al., 1999). EMA involves online tracking of articulator movements through the use of magnetic fields and receiver coils that are attached to the articulators. Currently, the relatively high cost of EMA would be prohibitive for most clinical use, and additional research is required to adequately document its effects.

Treatment Targets

Although most of the participants in the reviewed investigations presented with moderate to severe AOS (as described by the investigators), a relatively wide range of stimuli have been utilized as treatment targets. Frequently, short sentences or phrases have served as treatment stimuli (Bose et al., 2001; Cherney, 1995; Deal & Florance, 1978; Florance & Deal, 1977; Rosenbek et al., 1973). In such cases, a relatively limited number of target utterances of a functional or personal nature have been chosen for practice (e.g., My name is _____. It is time to go. I want to eat. What time is it?). Sentences have also been chosen to elicit production of specific sounds (Wambaugh et al., 1998b).

Single, real words have also often served as treatment targets. The words have sometimes been chosen for functional or individual reasons (e.g., Freed et al., 1997; LaPointe, 1984). More often, the words have been chosen to provide the opportunity to practice specific sounds (Aten, 1986; Howard & Varley, 1995; Knock et al., 2000; Square et al., 1986; Square-Storer & Hayden,1989; Wambaugh et al., 1998a, 1999; Wertz, 1984, 1998). The rationales provided regarding the selection of target sounds varied, but all selected sounds were those perceived to be problematic for the patients. Reasons provided for sound selection included the following:

1. relatively more success with selected sounds (Wertz, 1998);

2. need to expand phonetic repertoire (Aten, 1986);
3. need to achieve sound contrasts (Howard & Varley, 1995; Katz et al., 1999);
4. relatively high occurrence of errors (Wambaugh, 1998a); and
5. structure of the experiment (e.g., fricatives versus plosives) (Knock et al., 2000; Wambaugh et al., 1998b).

Isolated nonwords/syllables have been chosen specifically as treatment targets in a few AOS investigations (e.g., Kahn, Stannard, & Skinner, 1998; Katz et al., 1999; Maas et al., 2002). Both Katz et al. and Maas et al. indicated a desire for patients to focus on the sound/movement form. Interestingly, Katz et al. chose nonwords to allow this focus "without additional linguistic processing demands" (p. 1359), whereas Maas et al. utilized nonwords so that the patients would not "rely on semantics to activate a word form" (p. 613) (i.e., the semantic processing involved with real words was viewed as a potential hindrance in one case and as a potential facilitator in the other). An additional advantage of nonwords is increased experimental control of extraneous variables such as word frequency, familiarity, and imageability that may influence word retrieval in persons with AOS and co-occurring aphasia (Maas et al.). Positive results have been reported with the use of nonwords in such investigations (please note that Katz et al. employed additional stimuli beyond nonwords).

Other investigators have suggested that real words may be less difficult for persons with AOS and, consequently, may be preferred as treatment targets over nonwords (Howard & Varley, 1995; Kahn et al., 1998). For example, Howard and Varley noted that their patient with AOS "found it much more difficult to produce speech sounds in isolation or in nonsense words than in real, meaningful words" (p. 251). Findings from a case study by Kahn et al. indicated that target sounds were produced at higher accuracy levels when the sounds occurred in real words as opposed to nonwords. Despite the lack of data to support the selection of either real or nonwords as treatment targets at this time, it appears that this issue may be an important consideration when selecting treatment stimuli for some individuals with AOS.

Individual sounds and sounds in syllables (including syllables that resulted in real and nonwords) have also served as the targets of treatment (Dabul & Bollier, 1976; Holtzapple & Marshall, 1977; Knock et al., 2000; Raymer et al., 2002). Knock et al. selected CV and VC syllable shapes reportedly on the basis of stimulability and embedded the sounds of interest (stops and fricatives) within those syllables. The other approaches utilizing individual sounds and syllables involved progressing from isolated sound productions to various syllable shapes on the basis of predetermined treatment criteria. As discussed by Odell (2002), hierarchies of articulatory difficulty have been proposed for use in the treatment of AOS. However, there are currently no data available to support the notion that it may be necessary to proceed from "simple" sounds (e.g., vowels and developmentally early consonants) to more complex sounds and phonetic contexts. In fact, Maas et al. (2002) provided preliminary findings that suggested that some speakers with AOS may exhibit superior patterns of generalization when treatment is applied to clusters rather than to singletons.

Outcomes

Across the investigations, outcome measures were described under the heading of dependent variables; these were the behaviors that served as indices of treatment effects. The outcomes were further described with respect to the measurement of generalization and maintenance.

In most articulatory-kinematic investigations, probes specific to the focus of treatment were employed to evaluate treatment effects. Infrequently, formal test scores were also used as outcome measures (e.g., Aten, 1986; Dabul & Bollier, 1976; Florance & Deal, 1977; Stevens, 1989; Wertz, 1984), although these were usually utilized in addition to probe data. The dependent measures in the majority of investigations would be considered to reflect functioning at the level of "articulation function" according to the World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF; WHO ICF, 2005). Frequently, perceptual assessments in the form of phonetic transcriptions or various ratings/descriptors of accuracy were utilized to measure speech production. In only one instance (Florance & Deal, 1977) did a treatment focused on improving accuracy of speech production include an outcome measure that would be characterized as reflecting the WHO's ICF level of "activity and participation." Florance and Deal (1977) included a measure of "communicative success" to evaluate the effects of a treatment designed to improve production of 10 target sentences.

As indicated earlier, treatment outcomes have usually been reported to be positive. Only one articulatory kinematic investigation found treatment to be largely unproductive: Aten (1986) reported nega-

tive findings for 28 sessions of a treatment that was directed toward improved production of fricatives with a speaker with severely limited verbal production skills. Therapy included practice of nonspeech activities as well as practice of CV and CVC words with "intensive multimodal stimulation"(p. 128). Limited improvement was noted for only one of the four trained sounds.

Other treatments that have focused on production of specific sounds have reported positive gains in sound production for the majority of trained sounds. In a few cases (Raymer et al., 2002; Wambaugh et al., 1998), certain sounds have been relatively resistant to treatment even when other sounds have improved.

The data suggest that training a sufficient number of exemplars (e.g., 8–10 different phonetic contexts) of a targeted sound is likely to result in increased accuracy of production of untrained exemplars of that sound (Maas et al., 2002; Raymer et al., 2002, Wambaugh et al., 1998a, 1998b, 1999). In cases where a limited number of exemplars of targeted sound have been used, generalization to untrained exemplars has not occurred (Knock et al., 2000; Austerman, 2004 [not included in evidence table]). The data also indicate that production of untrained sounds is not likely to occur. That is, treatment effects appear to be largely sound specific. However, a few instances of limited and variable generalization to untrained sounds have been reported (Raymer et al., 2002; Wambaugh et al., 1998). In addition, qualitative measurements that include indicators of partial change may reveal subtle changes in untrained sounds that may not be detected by "correct-incorrect" scoring methods (Square-Storer & Hayden, 1989).

Treatments that have targeted production of selected words, phrases, or sentences (without a focus on specific sounds) have also generally resulted in item specific improvements. However, Bose et al. (2001) found that PROMPT may promote across sentence generalization effects within, but not across, sentence types. At the current time, there is insufficient information to determine how linguistic context may or may not influence the outcomes of AOS treatments.

Participants and Candidacy Issues

A total of 87 participants were studied across the 30 articulatory-kinematic treatment investigations. Two larger investigations, Florance and Deal (1977) and Wertz (1984), included 15 and 17 participants, respectively. The remainder of the investigations included between 1 and 5 participants, with 1 being the modal number.

Of those participants for whom severity ratings were available, 84% were provided a "severe" rating, 5% a moderate-severe rating, 9% a moderate rating, and 2% a mild-moderate rating. In comparison to the total group of 146 AOS participants studied across all investigations, the participants in the articulatory-kinematic investigations were more frequently rated as severe and none received a "mild" severity rating.

In terms of candidacy for articulatory kinematic treatments for AOS, obviously the patient should wish to improve speech production. Several of the treatments were specifically designed for speakers who were mute (Simpson & Clark, 1989) or had verbal productions limited primarily to stereotypies (Stevens, 1989). Others that provide biofeedback or tactile stimulation carry the implication that the patient may be deficient in utilizing proprioceptive information available through normal means. Treatments that focus on improved production of specific sounds may require that the patient demonstrate a degree of consistency in production of errors. For most of the treatments, basic candidacy criteria would include disrupted speech production with sufficient auditory comprehension to following instructions.

Level and Quality of Evidence

As reported by Wambaugh et al. (2006a), more than half of the investigations of articulatory kinematic treatments were experimental in nature, with a total of 15 single subject designs and one experimental group design. Internal validity was evident for 14 of the 29 investigations. As described previously, the AAN classification system was used to rate the quality of the evidence: a total of 14 investigations were described as Class IV, an additional 14 were described as Class III, and one was described as a "possible" Class II (see evidence table).

According to the AAN evidence classification scheme, a Level B rating may be assigned when there exists "at least one convincing Class II study or at least three consistent Class III studies" (Rutschmann et al., 2002, p. 1838). The data indicate that articulatory kinematic treatments, as a whole, could be considered "probably effective" (i.e., interpretation of Level B assignment) for AOS.

Conclusions

Articulatory kinematic treatments for AOS are likely to provide gains in speech production for individuals with AOS even when deficits are chronic and

severe. Although the majority of participants studied with these techniques have had "severe" speech/language disorders, application with individuals with less severe deficits does not appear to be precluded. However, data are required to establish the effects of articulatory kinematic approaches with such patients.

Most of the described treatments involved a combination of techniques. With the exception of Simmons (1980), there have been no component analyses of combined techniques. Furthermore, there have been few replications of any given treatment (Wambaugh, 2002). Consequently, these conclusions apply to the group of treatments rather than to any one specific treatment or technique.

Rate and/or Rhythm Treatments

The effects of either a rate control or rhythm control treatment for AOS were examined in seven investigations (Table 2). Rate and rhythm control were considered as one general treatment approach in this review because with each type of control, both rate and rhythm are impacted during the treatment process.

Rationale

An underlying premise of the treatments that have focused on rhythm and/or rate is that AOS is characterized by disruptions in the timing of speech production (Dworkin & Abkarian, 1996; Tjaden, 2000; Wambaugh & Martinez, 2000). Furthermore, rhythm is considered to be an essential component of the speech production process. It has been suggested that rhythm control treatments for AOS may help to re-establish temporal patterning (or metrical processing, Brendel et al., 2000). More specifically, it has been hypothesized that central pattern generators (CPGs) are involved in speech production (Barlow, Finan, & Park, 2004) and may be dysfunctional in AOS (Dworkin & Abkarian, 1996). Rhythmic treatments, such as metronomic pacing, are a form of entrainment (phase-locking of movements/rhythms), which may help to reset or improve function of CPGs (Wambaugh & Martinez, 2000).

Use of rhythmic treatments with AOS have incorporated reduced rate as part of the rhythm control (note: Brendel et al. [2000] controlled rate, but it is unclear if a reduced rate was used). Although speakers with AOS typically exhibit reduced rate, further slowing of speech production is thought to provide additional time for motor planning and/or programming as well as for processing of sensory feedback.

Several suggestions regarding attentional motivations for employing rate/rhythm controls have been made. Dworkin et al. (1988) suggested that their metronomic treatment may have served to focus the patient's attention on the need for additional precision in speech production. Conversely, Brendel et al. (2000) hypothesized that their rhythmic control treatment may have provided an external focus of attention in that attention may have been directed towards matching the external stimulus and was consequently drawn away from the actual speech movements.

Techniques

In the seven rate/rhythm investigations, an external source of control was applied to the speaker's productions. Three of those investigations employed metronomic pacing in repeated practice of targeted productions (Dworkin & Abkarian, 1996; Dworkin et al., 1988; Wambaugh & Martinez, 2000). Rates of production, in terms of beats per minute (bpm) of the metronome, varied across and within investigations. Dworkin and colleagues initiated treatment tasks at extremely slow rates of production (e.g., 15 or 30 bpm) and gradually increased to 120 bpm. Wambaugh and Martinez began treatment at 93 bpm in order to increase the speaker's word durations by approximately 50% over his typical durations. They also increased rate over the course of the investigation and eventually introduced a syncopated rhythm to approximate a more natural speech rhythm.

In the metronomic pacing investigations, target productions (see below) were entrained to the beat of the metronome. Additional techniques were employed in these investigations. Wambaugh and Martinez (2000) provided verbal feedback regarding the accuracy of the speaker's timing of production to the beat, but did not provide feedback regarding sound production accuracy. They also utilized clinician modeling and hand-tapping as part of their treatment. Dworkin and colleagues did not discuss the use of feedback and their treatment appeared to involve relatively independent practice of a large number of treatment trials at various levels of production. Dworkin et al. (1988) eliminated use of the metronome in their final stage of treatment and, instead, utilized a question-answer format with previously treated sentences.

Computerized control and/or feedback has been utilized to control rate (Southwood, 1987) or rhythm of production (Brendel et al., 2000; Tjaden, 2000). To control rate of word production during oral reading,

TABLE 2. Rate and/or rhythm control reports.

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Brendel (2000)	2–3 syllable words produced with carrier phrase; other levels?	participants not described; assumed to have severe AOS	treatment resulted in increased fluency for the three "pilot" participants (reduced pausing) as well as reduced segmental errors for one participant. The remaining two patients received synchronous treatment alternating with conventional treatment. One of those patients showed reduced utterance durations after both the conventional and synchronous treatments with no decrease in segmental errors. The other patient demonstrated reduced utterance durations following the synchronous treatments but not after the conventional treatments. Segmental errors also were reduced following the synchronous treatment.	p-values (Wilcoxon) were provided for the "pilot" participants. However, no experimental controls were employed, so results are questionable. In particular, no descriptions were provided of the participants, so that spontaneous recovery may have been a confound.
Dworkin (1996)	V, vowel sequences, V+/h/	patient with severe AOS and problems with volitional control of phonation	rhythmic stimulation facilitated control of phonation	no experimental control demonstrated, therefore alternative explanations exist for improved behavior; repetition alone may have produced the same effects

(continues)

TABLE 2. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Dworkin (1988)	nonspeech w/bite block; AMR; multisyllabic words; sentences	individual with moderate-to-severe AOS and anomia with relatively spared auditory comprehension and writing	treatment gains included "greater consistency and precision for individual sounds, words, and word combinations . . . less numerous articulatory breakdowns, groping, and transposition errors . . . closer to normal speaking rate and less disruption to speech intelligibility" (p. 289); author addresses the question of efficiency in terms of adjusting the criteria to advance in the treatment steps	study lends support to the efficacy of metronome pacing in that targeted behaviors improved and that there were associated moderate gains in untreated contextual speech; it is difficult to judge generalization as generalization to spontaneous speech seemed weakly supported by the data and generalization to untreated behaviors was not tested; of interest is that the data did not support hypothesis that "successful performance at an earlier step in the treatment regimen generalized to a later" (p. 287) (i.e., generalization to untreated levels (oromotor, AMR, words, sentences) was not observed)
McHenry (1994)	varied	patient for whom reduced rate or intersystemic facilitators increase intelligibility	"reducing speaking rate by pacing, phonetically transcribing words" minimized apraxia of speech	evidence for rate reduction with the use of a pacing board without concomitant evidence for an improvement in intelligibility or other AOS behaviors
Southwood (1987)	reading passages	patients with mild-moderate AOS	prolonged speech at reduced rate improved phoneme production in AOS	concur with author
Tjaden (2000)	reiterant speech—Dadada (later paired with words)	patient with mild AOS with scanning type speech production	treatment was not beneficial	no apparent benefit
Wambaugh (2000)	multisyllabic words	patient with moderate-mild AOS with difficulty in production of multisyllabic	rate and rhythm control can facilitate improved accuracy of sound production	concur with author's interpretation

Southwood used a computer display to present words for oral reading at specified rates, ranging from approximately 30 words per minute (wpm) to 130 wpm. A prolonged manner of speech production was encouraged to effect the desired decrease in rate. Brendel et al. required speakers to match their productions to computer-generated "rhythmic cues," which were adjusted for rate and metrical form (note: the nature of the cues and their integration into the treatment process was not described). In an attempt to improve stress-patterning, Tjaden provided computer-generated feedback in the form of a waveform display and a numerical indicator of syllable isochronicity (this reflected the duration of the stressed syllable to unstressed syllable) following the speaker's productions. Productions were also played via loudspeaker to provide auditory feedback.

In the remaining investigation (McHenry & Wilson, 1994), rate control was apparently employed through the use of a pacing board as well as through self-monitoring. However, the techniques employed were not specified, and it is unclear whether rate control was instituted due to the patient's AOS or his dysarthria. Furthermore, other techniques such as articulation drill and provision of phonetic information were seemingly employed.

Treatment Targets

The types of productions that have been targeted for treatment with rate/rhythm strategies have varied and, in most investigations, have been systematically manipulated in terms of perceived increased complexity. For example, Dworkin et al. (1988) began treatment with a bite-block activity in which the speaker raised and lowered her tongue tip to the beat of the metronome. Treatment progressed to alternate motion rate (AMR) practice, then to multisyllabic word practice, and finally to sentence production. Other treatment targets have included reiterative nonsense syllables (e.g., dadada; Tjaden, 2000), isolated vowels and vowel combinations (Dworkin & Abkarian, 1996), and oral reading (Southwood, 1987).

Outcomes

Measurements of behavioral change took numerous forms in the rate/rhythm control studies. In two investigations (Southwood, 1987; Wambaugh & Martinez, 2000), the effects of treatment were measured on accuracy of sound production. In both investigations, improvements in sound productions were reported despite the fact that no direct sound training had occurred. Wambaugh and Martinez reported that positive changes in sound production occurred for trained words as well as for untrained words with the same stress pattern. Results were mixed in terms of generalization to untrained words with different stress patterns. Of interest is the fact that the findings by Southwood (1987) and Wambaugh and Martinez (2000) are in conflict with an early nontreatment investigation by Shane and Darley (1978) in which patients with AOS did not improve in articulatory accuracy with paced oral reading tasks. Differences in the independent variables employed in these investigations, such as length of application of treatment and method of rate control, may have contributed to these differences.

Dworkin and colleagues measured the acceptability of productions (reflecting presence or absence of symptoms of apraxia) across all trained behaviors and found positive changes for those trained behaviors (Dworkin & Abkarian, 1996; Dworkin et al., 1988). Dworkin and Abkarian reported that treatment effects did not extend to untrained behaviors (e.g., treatment of oroneuromotor behaviors did not result in improved performance with AMRs). In light of the lack of response generalization, it is surprising that Dworkin and Abkarian reported improved ratings of elicited discourse. Dworkin et al.'s (1988) response generalization findings differed from Dworkin and Abkarian (1996) in that Dworkin et al. found positive generalization to more complex behaviors as a result of training voicing control with metronomic pacing.

Brendel et al. (2000) measured the effects of treatment in terms of segmental errors and behaviors that reflected fluency (e.g., utterance duration, time required for false starts and self-corrections, and intersyllabic pause time). The investigators reported increased fluency for all of the participants, with improvements in segmental productions varying across participants.

McHenry and Wilson (1994) documented a decrease in rate of speech production in picture descriptions and monologues with use of a pacing board in their case study. Southwood (1987) also reported decreased rate with the use of the computer controlled stimuli presentation and prolonged speech.

Tjaden (2000) reported no benefits from a treatment that targeted speech prosody with a speaker with mild to moderate AOS. The prosodic treatment involved repeated practice of reiterative syllables and multisyllabic real words with visual and auditory feedback to promote increased "temporal variation of adjacent syllables" (p. 621). Tjaden found

that accurate performance in the therapy task did not generalize to production in probe sentences.

Participants and Candidacy Issues

Rate/rhythm control treatments have been studied with a total of 12 participants. Severity was not reported for 5 of the participants (Brendel et al., 2000). Of the remaining 7 participants, severity descriptions were as follows: mild ($n = 2$), mild-moderate ($n = 2$), moderate ($n = 2$), and severe ($n = 1$). Considering that 67% of the total 146 AOS participants were described as having "severe" speech/language disruptions, the group of participants who received rate/rhythm treatments apparently had less severe symptoms.

No restrictions on candidacy were evident other than demonstration of need to improve behaviors that were amenable to practice using rate/rhythm techniques.

Level and Quality of Evidence

Four of the seven rate/rhythm control investigations were case studies. The remaining three investigations employed single-subject designs, with interval validity being evident.

The three investigations with internal validity were classified as Class III studies. As indicated previously, three consistent Class III studies may lead to a Level B rating according to the AAN evidence classification scheme. However, the investigation by Southwood (1987) could be considered a facilitation study rather than a true treatment investigation. Given the fact that the other two Class III studies each employed only one participant, an assignment of a Level B rating is not well supported. Rather, the evidence for rate/rhythm control treatments suggests a Level C rating, which reflects treatment that is "possibly effective."

Conclusions

Rate/rhythm control treatments for AOS may provide benefits for some individuals with AOS. Gains may be seen in the form of improvement of articulation, increased fluency, reduced rate, or decrease in overall AOS symptoms. The mechanism responsible for behavioral change is not well understood with these treatments. Comparative investigations are needed to determine whether repeated practice alone (i.e., without external control mechanisms) may produce similar improvements. The negative findings by Tjaden (2000) appear to be in conflict to the findings reported by Brendel et al. (2000) and are deserving of further investigation.

Intersystemic Facilitation/Reorganization Treatments

Rationale

Eight investigations were focused on the examination of the effects of treatments that reflected the concept of intersystemic facilitation/reorganization (Table 3). Intersystemic facilitation/reorganization involves the utilization of a relatively intact system/modality to facilitate functioning of an impaired system/modality (Rosenbek et al., 1976). With respect to the treatment of AOS, the facilitative effects are thought to be possibly derived from the provision of additional afferent or efferent cues. Additionally, it has been hypothesized that the use of limb gestures in reorganization may provide an organizational framework for speech production (Rubow et al., 1982).

Techniques

Gestural reorganization has been the most frequently studied type of reorganization with AOS. Of the six investigations that utilized a limb gesture approach to treatment, four employed meaningful gestures (e.g., Amer-Ind gestural code [Skelly, 1979]) and two used nonmeaningful gestures (e.g., finger-counting [Simmons, 1978], or hand-tapping [Wertz et al., 1984]).

In all but one investigation (Dowden et al., 1981), the gestures were paired with verbalizations (i.e., words or sentences) during treatment. Dowden et al. trained only gestural production, but measured the effects of treatment on verbal production.

Rubow et al. (1982) focused on the notion that additional afference may play a critical role in intersystemic facilitation/reorganization and employed externally generated vibrotactile stimulation in their treatment of AOS.

Singing has also been utilized in the treatment of AOS (Keith & Aronson, 1975) in a manner consistent with the concept of intersystemic facilitation/reorganization.

It should be noted that rate and/or rhythm control treatments possess similarities to intersystemic facilitation/reorganization treatments. In particular, the use of vibrotactile stimulation and nonmeaningful gestures could be considered to exert control over rate/rhythm. However, in these investi-

TABLE 3. AAC reports.

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Bailey (1983)	use of Blissymbols	AOS speaker with extremely limited verbal output	relieving frustration did not alleviate articulatory dyspraxia. Subject has objectively and functionally improved his communication skills and understanding of language	not convincing that Blissymbols improve communication skills, may be more due to the accompanying visual (written) language
Fawcus (1990)	use of total communication	patients with severe AOS who would benefit from using alternative mode of communication	treatment resulted in improved communication for all participants.	findings are questionable because no pretreatment measures were made/reported in the same condition. That is, only posttreatment data were presented.
Lane (1981)	use of Blissymbols	patients with severe AOS	candidates with good auditory comprehension, good visual-perceptual skills and a high level of motivation are more successful in using Blissymbols as a facilitating technique.	promising study for facilitation of communication in some patients with AOS.
Lasker (2001)	use of dynamic display device	patient with aphasia and AOS with limited verbal output	treatment was successful in getting patient to accept and use AAC	treatment may have worked, but there is no way to know if increased use of AAC is related to treatment or simply lots of practice or family support since this was an uncontrolled case study
Lustig (2002)	use of writing on occurrence of verbal struggle	patient with AOS who exhibits stuggle behavior that is problematic and who is able to write target words with a high level of success	treatment likely resulted in increases in the application of the writing strategy with concurrent decreases in abandoned topics; noted that treatment was initiated when an upturn had occurred in baseline; listeners perceived the patient as communicating more easily following treatment	authors' interpretation appeared to be correct

(continues)

TABLE 3. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Marshall (1988)	use of electrolarynx	individual with laryngeal apraxia with no supralaryngeal apraxia, good auditory comprehension and no limb apraxia	apraxia can selectively affect motor programming of the larynx and use of an electrolarynx in such cases is effective	approach warrants consideration
Rabidoux (1980)	use of Handivoice	severe AOS with normal or relatively good language skills and ability to manipulate AAC device.	text implies a conclusion that Handivoice use had a positive impact on patients' "life system"	lack of quantified stable baseline or post treatment measures of communication without Handivoice limit the "scientific" conclusions that can be drawn; however, authors' conclusions likely correct.
Yorkston (1989)	use of multiple communication modes	severe aphasia and AOS; individuals who communicate better than they talk, have some speech, some gestures, some spelling and drawing skills, but none are strong enough to carry the full burden for communication of all messages	all four individuals improved their ability to use augmentative communication with training and communicate specific information. These improvements were associated with a reduction of struggle behavior and apparent frustration	this article provides useful clinical information regarding the decision process involved in introducing and developing AAC for individuals with AOS

gations, the authors expressly indicated that treatment was devised to function as an intersystemic reorganizer, whereas in the rate/rhythm investigations, treatment was developed specifically to target rate/rhythm.

Similarly, the use of graphic stimuli in treatment could be considered to be a form of intersystemic facilitation/reorganization. Graphic stimuli have often been incorporated into treatment hierarchies, particularly treatments that have had a focus on articulatory kinematic aspects of AOS. No AOS treatments have used graphic stimuli exclusively. Because graphic stimuli appear to have been used primarily to supplement other techniques, they have been subsumed under other categories in this review.

Treatment Targets

Intersystemic facilitation/reorganization approaches have targeted verbal production at different levels within and across investigations, with targets including words, phrases, and sentences.

Outcomes

In most investigations, gestural reorganization appeared to facilitate verbal productions (Code & Gaunt, 1986; Raymer & Thompson, 1991; Simmons, 1978; Skelly et al., 1974; Wertz et al., 1984). In the only investigation in which gestures were trained without being paired to verbalizations, Dowden et al. (1981) found no changes in PICA verbal percentile scores. Positive changes in verbal productions were also reported following use of vibrotactile stimulation (Rubow et al., 1982) and singing (Keith & Aronson, 1975).

Improvements in verbal productions were documented in terms of improved accuracy of articulation (Raymer & Thomspon, 1991; Rubow et al., 1982; Wertz et al., 1984) as well as increases in test scores (Simmons, 1978; Skelly et al., 1974). The findings of Raymer and Thompson suggest that improvements in accuracy of articulation may be sound dependent. That is, Raymer and Thompson examined the acquisition and generalization effects of treatment within and across specific sounds (i.e., experimental words were selected as exemplars of certain sounds) and found different effects for different sounds. Additionally, generalization was variable to untrained sounds with similar manner and/or place of production. Furthermore, Raymer and Thompson examined effects of treatment across elicitation conditions and found changes to be greatest in a repetition condition, with limited changes in oral naming.

Maintenance of gains in verbal production was measured in only one investigation: Raymer and Thompson (1991) noted a decrease in accuracy of production of previously trained sounds during treatment withdrawal phases, with productions remaining above baseline levels. None of the intersystemic investigations included follow-up measures to examine maintenance beyond the conclusion of treatment.

In three of the four investigations that involved meaningful gestures, gestural productions were measured as well as verbal productions. Code and Gaunt (1986) and Dowden et al. (1981) reported increased accuracy of production of trained gestures following treatment. Raymer and Thompson (1991) noted increased use of gestures with oral naming attempts, but did not document accuracy of the gestures. In addition, Dowden et al. documented improved production of untrained gestures for one, but not both, of the participants in their investigation. Code and Gaunt also reported positive generalization effects of treatment to untrained gestures.

The outcome of intersystemic treatment has been compared with imitation-only treatment in two investigations. Wertz et al. (1984) compared hand-tapping plus imitation to imitation-only in the treatment of sentences, and Rubow et al. (1982) compared vibrotactile plus imitation to imitation-only in the treatment of words. Both found intersystemic treatment to have superior results in terms of improvements in verbal productions.

Participants and Candidacy Issues

Twelve of the 14 individuals who served as participants in the intersystemic facilitation/reorganization investigations were described as having "severe" symptoms. The severity of the remaining two participants (Rubow et al., 1982; Wertz et al., 1984) was described as "moderate."

Candidates for treatments involving gestural reorganization through the use of meaningful gestures such as Amer-Ind appear to be those with extremely limited potential for verbal output. The presence of limb apraxia may preclude utilization of a gestural approach, although the participant studied by Code and Gaunt (1986) evidenced some success despite the presence of significant limb apraxia.

Candidates for treatments utilizing nonmeaningful gestures (e.g., hand-tapping, finger-counting) should be capable of producing speech in the form of

words, phrases, or sentences in order to allow pairing of speech and gestural productions.

Level and Quality of Evidence

Four of the investigations were case studies and four involved single-subject designs. However, internal validity was evident for only two of the investigations (Raymer & Thompson, 1991; Wertz et al., 1984). Consequently, six of the investigations were rated as Class IV, and two were classified as Class III using the AAN classification scheme. These classifications are consistent with a Level C rating, indicative of treatment that is "possibly effective" (Rutschmann et al., 2002).

Conclusions

Intersystemic facilitation/reorganization treatments for AOS may be beneficial for some individuals with AOS. Gains may be evidenced in terms of improved articulation and, possibly, improved gestural abilities. Preliminary comparative investigations (Rubow et al., 1982; Wertz et al., 1984) suggest that the use of intersystemic facilitators/reorganizers may produce gains superior to treatment involving only imitation. However, due to the extreme brevity of one of these reports (Wertz et al.) and potential threats to internal validity in the other (Rubow et al.), further comparative studies are required prior to conclusions being drawn regarding the relative superiority of intersystemic treatment for AOS.

Alternative/Augmentative Communication Approaches

Rationale

The common motivation for the eight treatment investigations involving alternative/augmentative approaches was the perceived need to improve communication through the use of modalities other than speech (Table 4). That is, verbal communication was judged to be less than optimally effective and, consequently, methods for either circumventing or supplementing speech were devised.

Treatment Techniques/Approaches and Treatment Targets

With the exception of two investigations involving Blissymbols (Bailey, 1983; Lane & Samples, 1981), the AAC treatment approaches appeared to be largely individualized for each participant. However, some commonalities were evident across investigations. As illustrated by the Yorkston and Waugh's (1989) case studies, several general treatment approaches have been employed with individuals with AOS and aphasia.

Yorkston and Waugh (1989) indicated that a "comprehensive communication system" may be trained for maximal flexibility in application. They noted that such a system would likely entail incorporation of natural speech, a communication book/aid, a spelling system, a drawing system, a gestural system, and informed communication partners. Yorkston and Waugh described the successful utilization of a comprehensive communication system by individual with severe AOS and severe aphasia, but did not describe the specific training techniques utilized to achieve productive use of the system. Fawcus and Fawcus (1990) investigated the effects of a total communication approach that involved signing (Amer-Ind), mime, drawing, and writing. However, they did not describe the training approach other than to indicate that participants met as a group and that the focus of treatment was increased awareness of alternative communication strategies.

A second general strategy has been to train the use of a single alternative communication system, typically involving the use of symbols or pictures. Bailey (1983) and Lane and Samples (1981) investigated the effects of training Blissymbols (i.e., visual-graphic symbols). Both investigations included training of individual symbols, instruction in combining symbols, and group practice. Voice output communication aids have also been trained as alternative communication systems with individuals with AOS and aphasia (Lasker & Bedrosian, 2001; Rabidoux, Florance, & McCauslin, 1980; Yorkston & Waugh, 1989). Training techniques have ranged from instruction in provision of consistent yes/no responses (Yorkston & Waugh, 1989), to conversational practice (Rabidoux et al., 1980; Lasker & Bedrosian; 2001), and to role playing in simulated situations (Lasker & Bedrosian, 2001).

Another general AAC approach described by Yorkston and Waugh (1989) and evidenced in the AOS treatment literature is training of writing/orthographic systems. Bailey (1983) paired production/reception of the written word with instruction in Blissymbols. The participant eventually moved from using a Blissymbol chart to a written word board. Lustig and Tompkins (2002) employed a writing strategy with an AOS speaker who demonstrated persistence in verbal struggle behavior.

TABLE 4. Intersystemic facilitation/reorganization approaches.

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Code (1986)	production of words	patient with very limited potential for improved verbal output	treatment was successful in training gestures and words	possible positive, but limited effects; patient correctly produced only 4 of 10 trained gestures
Dowden (1981)	production of gestures and words	AOS speaker with severely limited output	gestures may serve as an alternative communication mode in severe AOS-aphasia; need to train in natural contexts; does not facilitate verbal communication	difficult to judge if the relatively small amount of improvement could be attributed to treatment
Keith (1975)	naming, sentence completion, phrase production	severe AOS with limited sound repertoire, even in response to verbal cuing	singing therapy allowed patient to sing words she could not say	completely unconvincing, purely descriptive study, conducted during spontaneous recovery period, without controls; fair to conclude that—just before singing text was begun—singing helped elicit intelligible verbal responses that could not simply be spoken
Raymer (1991)	words with specific initial sounds	Patient with relatively severe AOS but some ability to produce syllable level speech	severely impaired patient can improve in only some aspects of verbal production with the addition of gestures—only during repetition not naming; increases in gestural productions were also noted; postiive results for trained /s,f,l/, but not for /t/ ("unable to learn")	treatment effects most evident for repetition, but decrease in performance during withdrawal phases somewhat problematic
Rubow (1982)	words with initial plosive or fricatives	individual with moderate AOS with lexical stress abnormailities	vibrotactile plus auditory stress and rhythm cues were more effective than auditory cues alone to improve articulation of polysyllabic words	the fact that the two treatments were applied to two sets of polysyllabic words differing in the manner of articulation introduces a confound; also, the method of rating the patient's productions is not clearly described so the results are difficult to interpret

(continues)

TABLE 4. *(continued)*

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Simmons (1978)	SVPP sentences	patient who can imitatively produce at least short phrases or sentences	improvement seen following finger counting treatment; probable that treatment served as an intersystemic reorganizer	no experimental control demonstrated, therefore alternative explanations exist for improved behavior.
Skelly (1974)	words	probably Ss with severe AOS and limited or no verbal output, with or without aphasia, but better PICA Gestural and Graphic skills	study warrants further exploration of Amerind sign as a facilitator or oral verbalization for apraxic pts because 5/6 treated patients made progress	agree with authors' interpretation; the report justified further investigation; but, the level of evidence in this study is weak
Wertz (1984)	/st/ (i) words; sentences	patient with moderate AOS —with need to improve sound production in words	positive effects of treatment; superiority of gestural over imitation alone	data are sketchy, but support author's conclusions

They instructed the participant to use a written response when spoken responses occurred with struggle behavior. Sets of conversational topics served as the treatment stimuli, with treatment being applied first with the clinician and later with unfamiliar conversational partners.

An additional treatment focus has been promotion of acceptance of AAC (Lasker & Bedrosian, 2001). That is, potential AAC users may not readily accept or optimally utilize AAC options. Consequently, treatment may need to be structured to facilitate maximal utilization of AAC options. For example, Lasker and Bedrosian reported a case in which an individual with chronic aphasia and AOS demonstrated reluctance in utilization of an AAC device in situations beyond the speech/language clinic. A community-based treatment approach was implemented that involved role play and practice during community outings.

A unique case of apraxia of phonation was described by Marshall et al. (1988). In this case, apraxia apparently selectively affected motor programming of the larynx. The investigators utilized an electrolarynx to circumvent the difficulties with phonation.

Outcomes

Positive outcomes were reported for most of the participants in the AAC investigations. Outcome measures varied according to the focus of the treatment and included the following: formal speech/language test scores (Bailey, 1983; Rabidoux et al., 1980), mean length of utterance (Rabidoux et al., 1980), adequacy of conveyance of predetermined utterances (Fawcus & Fawcus, 1990), communicative success (Lasker & Bedrosian, 2001; Rabidoux et al., 1980), acquisition of symbols (Lane & Samples, 1981), and self-initiation of a writing strategy (Lustig & Tompkins, 2002).

Lustig and Tompkins (2002) employed a comprehensive strategy of outcome measurement. In addition to measuring the use of the behavior targeted for treatment (i.e., employment of a writing strategy when verbal struggle occurred), they utilized self-reported measures of psychosocial well-being (i.e., Communication Attitude Inventory, Andrews & Cutler, 1974; Recovery Locus of Control Scale [RLOC], Partridge & Johnson, 1989; and Rosenberg Self-Esteem Scale, Rosenberg, 1965). Furthermore, they obtained ratings from unaffiliated raters regarding several aspects of videotaped pre- and posttreatment conversational exchanges. Lustig and Tompkins reported substantial increases in use of the writing strategy following treatment. Training with the clinician in a private setting resulted in generalized responding to conversations in a public setting with the clinician, but not to conversations with unfamiliar partners. When training was instituted in the unfamiliar partner setting, strategy use with unfamiliar partners increased. No changes were evident on the measures of communication attitude and self-esteem following treatment. However, Lustig and Tompkins noted that the participant's responses to the RLOC indicated a lessening of a strongly internal locus of control. With respect to the social validity rating, the investigators found significant positive posttreatment changes in ratings of "short" video clips (i.e., 20 seconds), but no significant changes in ratings of "longer" clips (i.e., 2–4 minutes). Various uncontrolled confounds, including linguistic impairments, were thought to contribute to the differences in ratings of short and long clips.

Although Bailey (1983) reported improved language functioning following training with Blissymbols, the use of the symbols was considered to be valuable as a training technique, but not as an alternative communication system. Specifically, the participant reportedly began to rely on the written words paired with the symbols and eventually discontinued use of the symbols. Lane and Samples (1981) also examined the effects of treatment focused on Blissymbols, with treatment being applied in a group setting. They reported that after training, only one of the four participants used Blissymbols on a self-initiated basis. Another participant demonstrated increases in identification of the symbols, utilized writing paired with symbol practice, and appeared to be moving toward functional use of the symbols. The investigators noted that the remaining two participants displayed unwillingness to use an alternate means of communication.

All other outcome reports were positive in the remaining AAC investigations.

Participants and Candidacy Issues

Nineteen individuals served as participants across the nine AAC investigations. Severity descriptions were provided for 17 of the participants. The speech/language disruptions of the participants were described as "severe" in all but one case (i.e., the participant in Lustig and Tompkins' investigation (2002) was described as having a moderate-severe disorder).

Issues related to candidacy for an AAC approach are not unique to AOS. Individuals must be motivated to use an alternative/augmentative system and must have adequate motor skills to employ an AAC device/system. Although Code and Gaunt (1986) documented acquisition of gestural skills in their study of intersystemic facilitation/reorganization with a patient with limb apraxia, limb apraxia may be a limiting factor in the consideration of an AAC approach. Candidates should also possess sufficient visual perceptual skills. Lane and Samples (1981) reported that two participants with homonymous hemianopsias required larger sized Blissymbols and noted that larger symbols may be impractical.

Language disruptions associated with concomitant aphasia should be taken into account in the consideration of an AAC approach. Lane and Samples (1981) reported that the two participants who demonstrated better performance with Blissymbols had better auditory comprehension skills than the two participants who did not make gains with Blissymbols. In addition to the ability to comprehend verbal language, reading and writing skills may factor into the choice of an AAC device/system (Rogers, 2001). For the AAC strategy employed by Lustig and Tompkins (2002), writing skills should be superior to verbal skills.

Level and Quality of Evidence

Seven of the eight AAC investigations were case reports and consequently, received ratings of Level IV using the AAN scheme. The remaining investigation (Lustig & Tompkins, 2002) employed a single-subject experimental design. Although it was unclear as to whether all outcome assessments were independent of treatment, Lustig and Tompkins' investigation was rated as a Level III. Overall, the level and quality of evidence regarding AAC options in the treatment of AOS was inadequate to make any determination regarding treatment effects.

Conclusions

AAC approaches may be appropriate for some individuals with AOS who have extremely limited verbal output or who have communication needs that cannot or are not likely to be met by the individual's speech production skills. However, there are insufficient data currently to serve as a guide for predicting whether AAC approaches may be successful. The type and extent of co-occurring symptoms of aphasia should be considered in the AAC selection and treatment process. Successful use of an AAC device/system may be heavily dependent upon the nature of the aphasia.

AAC systems/devices may serve a temporary or more permanent communication means; however, only cases in which the AAC system was viewed as potentially permanent have been reported. Clinical utilization of AAC methods with individuals who present with AOS in the acute, potentially resolving phase, is likely to be relatively widespread and not reflected in the published literature. Much more extensive, controlled documentation of the effects of AAC training with individuals with AOS is obviously needed.

Other Treatments

Five investigations could not be categorized according to any of the previously discussed treatment categories (Table 5). Additionally, the treatments described in these investigations were dissimilar to each other and could not be evaluated as a group.

Florance and Deal (1979) described a treatment designed to "increase the conversational abilities of the moderately impaired apraxic patient" (p. 184). The investigators employed a case report to describe a progression of practice from sentence level stimuli, to pseudoconversations, to home treatment with the spouse. Although Florance and Deal indicated that this treatment was not an articulatory approach, aspects of the treatment could be considered articulatory-kinematic in nature. That is, repeated verbal practice was used, unspecified auditory and visual production cues were utilized, and off-target word and phoneme errors were recorded.

Florance, Rabidoux, and McCauslin (1980) also emphasized conversational skills in a report of three cases with individuals with severe AOS. However, the focus of treatment was on training of significant other persons (SOPs) in interviewing techniques. In addition, one participant received training in self-monitoring and self-regulation. Although, dramatic increases in mean length of utterance and "communicative success" were reported, the uncontrolled nature of the reports limits the utility of the findings.

Hadar et al. (1984) described a unique approach designed to improve segmental and suprasegmental aspects of speech production by practicing nonspeech and speech movements paired with head movements. Unfortunately, this case study did not provide substantiated data to support claims of improved speech fluency.

TABLE 5. Other approaches.

First Author (Year)	Treatment Targets	Candidacy Summary	Author's Interpretation	Rater's Interpretation
Florance (1979)	sentences alone and in pseudoconversations	individual with moderate to severe AOS who have ability to produce words "easily" with audio-visual stimulation and cueing	"program was successful in facilitating improved conversational ability" (p. 190)	case study design limits conclusions that can be drawn; however, patient was certainly chronic; additionally, patient's spouse may have been biased in recording of novel uttereances at home given her role in treatment; results appear promising
Florance (1980)	for 2 participants, SOPs applied techniques in everyday communication; for 3rd participant, 10 stimulus-	AOS with decreased MLU and communicative success	for each of the patients, improved communicative ability lead to more independent self management of total life sysems	significant increase in MLU is reported, without statistical analysis provided; no experimental control evidenced
Hadar (1984)	head movements	patient with expressive speech disorder and relatively preserved auditory comprehension	treatment resulted in overcoming motor difficulty; resulted in overcoming speech fluency problem	evidence provided is insufficient to make even preliminary speculations about the effects of this strange and poorly specified treatment program
McNeil (1976)	tension as detected from frontalis muscle	mild to moderate AOS with aphasia	all Ss relaxed with biofeedback; postest, combined feedback conditions for PICA Gestural and Verbal subtests were improved; interpreted as evidence of improved performance with relaxation	control insufficient to conclude biofeedback was responsible; even if it was responsible, it cannot be concluded the treatment had any specific effect on AOS-relevant variables (i.e., the improvement may have been in aphasia)
Warren (1977)	words	patients with verbal apraxia	patients with AOS demonstrated no rehearsal advantage in long-term retention of phonemes; this result questions the usefulness of response delays as a separate procedure in paradigms for AOS	no evidence was provided to support the hypothesis that rehearsal increases phonemic accuracy of speech in patients with AOS

McNeil et al. (1976) theorized that communicative failure associated with AOS and aphasia may result in increased anxiety and frustration with resultant muscle tension that could interfere with speech/language performance. Treatment involved provision of auditory and/or visual feedback based on EMG-read activity from the frontalis muscle to reduce muscle tension. Feedback was provided during a variety of language tasks and all participants demonstrated reduced muscle tension during feedback. Posttest PICA Gestural and Verbal scores were significantly higher with and without feedback for the group of apraxic/aphasic participants. A high degree of variability across speech/language tasks prohibited qualitative analysis of the effects of feedback.

Warren (1977) compared the effects of imitation versus silent rehearsal on number of correctly recalled phonemes in a confrontation naming task with five speakers with AOS and Broca's aphasia. Treatment exposure was limited to five sessions for each condition, so this investigation may be more accurately termed a facilitation study rather than a treatment study. Although positive changes in correct phoneme recall were noted for both conditions, no advantage was found for silent rehearsal.

RECOMMENDATIONS

In summary, articulatory kinematic approaches were determined to be "probably effective"; rate/rhythm control approaches and intersystemic approaches were considered to be "possibly effective"; and AAC approaches could not be rated in terms of likelihood of benefit. As indicated previously, these effectiveness determinations were based on the AAN classification scheme.

Effectiveness determinations relate directly to the strength of treatment recommendations. As discussed by Marcuse et al. (2004), the development of clinical practice guidelines should include the designation of recommendation strength, which "communicates the guideline developers' (and the sponsoring organizations') assessment of the importance of adherence to a particular recommendation" (p. 875). Like effectiveness determination, recommendation strength is based on evaluation of the quality and quantity of the evidence and the relative magnitude of potential benefits or harm/risks.

Recommendation strength designations are intended as interpretive aids for clinicians in their consideration of treatment guidelines. As noted by Marcuse et al. (2004), "guidelines are never intended to overrule professional judgment; rather they may be viewed as a relative constraint on individual clinician discretion in a particular clinical circumstance" (p. 876). The recommendation scheme suggested by the American Academy of Pediatrics (Marcuse et al.) was utilized for the present guidelines, with *potential* recommendation classifications as follows: strong recommendation, recommendation, option, and no recommendation.

A "strong recommendation" indicates that the committee believes that the evidence supporting the use of a treatment approach is of high quality and that benefits clearly outweigh risk/harm. Strong recommendations are relatively more restrictive of variation in clinical practice than any of the other classifications; such recommendations should be followed unless the clinician has clear evidence to the contrary. None of the AOS treatment approaches warranted a strong recommendation.

"Recommendations" are made when the committee considers benefits to clearly exceed risks, but the evidence to be less strong (i.e., AAN Classes II and III). Recommendations should usually be followed by clinicians, but clinicians should be responsive to patient preferences and should be watchful for new evidence concerning the approach (Marcuse et al., 2004). The committee recommends that articulatory kinematic approaches be utilized with individuals with moderate to severe AOS who demonstrate disrupted communication due to disturbances in the spatial and temporal aspects of speech production.

Treatments are designated as "options" when the evidence base is suspect or there is not a clear preponderance of benefit over risk/harm. Options place little restriction on clinical practice. Treatment options are just that; clinicians should be aware of such treatments as potentially viable approaches, but clinician and patient preference should have a considerable role in the decision-making process. As with recommendations, clinicians should be attentive to new literature pertaining to the treatment option. The committee believes that AOS rate/rhythm control approaches, intersystemic treatments, and AAC approaches should be considered treatment options.

The committee's recommendations are not intended to imply that articulatory kinematic approaches should be preferred over the other approaches. Certainly, the quantity and quality of the evidence supporting the use of articulatory kinematic approaches is superior to the evidence for the other approaches at the current time. However, there are insufficient data (specifically, comparative studies) to suggest that any one approach would be

more beneficial than another for a given individual with AOS.

CONCLUSIONS AND FUTURE RESEARCH NEEDS

Taken as a whole, the AOS treatment literature indicates that individuals with AOS may be expected to make improvements in speech production as a result of treatment, even when AOS is chronic. The strongest evidence for this conclusion exists for treatments designed to improve articulatory kinematic aspects of speech production. However, the quantity and quality of this evidence is not optimal. Promising, but limited evidence is available to support the use of other treatments for AOS.

It is obvious that additional research is required to replicate the encouraging results obtained in numerous AOS treatment investigations. The AOS literature is typified by solitary investigations in which one or a few subjects demonstrated positive outcomes, with no follow-up investigations to verify or extend the findings. Systematic, sustained examinations of the full range of effects of AOS treatments are needed to move this area of inquiry and clinical practice forward.

Within Robey and Schultz's (1998) five phase model of clinical outcome research, AOS treatment development would be best characterized as at the Phase-I or Phase-II levels. That is, the existing AOS treatment research represents the early phases of preparation for efficacy testing (note: discussion of other stages of the model will follow in subsequent sections). For most AOS treatments, the answers to basic questions that are typically addressed in Phase-I investigations are not yet available. As discussed by Robey and Schultz, "Phase-I research begins with observations designed to detect the presence of a therapeutic effect . . . A favourable outcome in this initial step warrants further observations for (a) replication, (b) testing variations on the treatment protocol, (c) testing variations in subject characteristics, and (d) estimating appropriate dosage" (p. 795). The vast majority of AOS treatment investigations have addressed merely the issue of the existence of a treatment effect.

Only in the cases of PROMPT (Bose et al., 2001; Freed et al., 1997; Square et al., 1985, 1986), sound production treatment (SPT; Wambaugh et al., 1996, 1998; Wambaugh & Martinez, 2000; Wambaugh, West, & Doyle, 1998), and the eight-step continuum (Deal & Florance, 1978; Rosenbek et al., 1973; Simmons, 1980) have treatment effects been replicated across subjects with different characteristics and across variations in treatment protocols. Other elements of Phase-I and II treatment development enumerated by Robey and Schultz (1998) have rarely been addressed (e.g., determining criteria for discharge, establishing reliable treatment administration, establishing maintenance effects, defining/optimizing treatment environments, and developing/standardizing instruments to measure treatment effects). A few of the issues that the committee considered to be especially important in terms of Phase-I and Phase-II AOS treatment research will be discussed in following paragraphs.

Definition and Description of AOS

A critical aspect of treatment development and testing involves defining the clinical population for whom the treatment is intended (Robey & Schultz, 1998). As illustrated by the committee's ratings of confidence in the diagnoses of AOS, most AOS treatment investigations have provided incomplete/inadequate descriptions of the discriminative characteristics of AOS. In addition, it was difficult for the committee to judge severity of AOS in most investigations. Insufficient descriptions are not conducive to delineating target populations in Phase-I and Phase-II research. In later phases of efficacy and effectiveness testing (Phases-III through V, see below), thorough participant descriptions are also important for strengthening external validity.

At the current time, there is no published AOS diagnostic test that permits reliable identification of AOS. There is also no formal consensus—based on up-to-date research findings—about deviant speech characteristics that must be present for a diagnosis of AOS (Croot, 2002). It is imperative that future AOS treatment reports include sufficiently detailed descriptions of the participants' speech behaviors to provide confidence in the diagnosis of AOS. Although there is no agreed on measure of AOS severity, adequate descriptions would permit better comparisons of speech production abilities among participants. Furthermore, given the relative paucity of AOS treatment data, it is important that sufficient participant descriptions are available for clinicians to assess similarities and differences between the research participants and the patients for whom they are considering treatment.

Ideally, AOS treatment investigators should be clear about the characteristics they consider definitive of AOS and should provide data concerning the occurrence of those characteristics (or at least examples of the participants' speech behaviors that

reflect the characteristics). Co-occurring conditions that could impact verbal production, such as aphasia, dysarthria, and nonverbal oral apraxia should be thoroughly described as well.

Measurement of Treatment Effects

As described in the previous "Outcomes" sections, outcome measurements have varied widely across investigations. They have typically been limited in scope and closely related to the trained behaviors. Of course, such measures are necessary in Phase-I investigations which seek to document evidence of a treatment effect. However, future investigations should include more extensive evaluation of the range of treatment effects (for example, see Lustig & Tompkins [2002]). The relationships between measures of speech impairment and measures of potentially more complex aspects of communication (e.g., activity limitations, participation restrictions, psychosocial well-being, and social validity) are certainly not well understood. It is likely that a significant amount of research devoted to the development of appropriate measures will be required to fully understand the range of effects of AOS treatments.

Treatment Development and Testing

It is beyond the scope of this report to review the process of treatment development and testing described in various models of clinical-outcome research (see Robey and Schultz [1998] for a review). Robey & Schultz's model for conducting clinical outcome research in aphasiology appears to be *generally* appropriate for use in the area of AOS. As the phases of the model progress from preliminary Phase-I and Phase-II research, more stringent experimental controls with relatively large numbers of participants are required for Phase-III, efficacy testing. Phases IV and V proceed from efficacy testing to effectiveness testing and also require larger numbers of subjects. It is essential that researchers move forward through such a model to advance evidence-based AOS treatment. However, it should be noted that although randomized, controlled trials (RCTs) are typically considered the ideal in terms of quality of evidence, such trials may not be a realistic goal for the study of AOS treatments. Controlling for factors such as the heterogeneity of speech disruptions associated with AOS and the ubiquitous co-occurrence of additional confounding language/speech disorders may preclude obtaining the necessary sample sizes required for RCTs. Future efforts should be made to determine appropriate and feasible experimental methods for providing the highest quality of evidence for the treatment of AOS.

The Need to Update Guidelines

Future research will provide a more substantial base of evidence for use in guiding clinical practice in the management of AOS. The ANCDS Writing Committee of Treatment Guidelines for AOS will monitor new AOS treatment research developments in order to provide updated guidelines. A firm timeline for updating has not been established. Updating will be dependent on one of the following criteria being met:

1. five years have elapsed since the last review,
2. thirty new investigations have been published (approximately 50% of the number of investigations in this review), or
3. several new Phase-I or Phase-II studies have been published that contraindicate recommendations from this review.

Despite significant inroads being made concerning the treatment of AOS, much remains unknown. Given the current state of clinical AOS research, the committee was limited to the provision of treatment recommendations and options. More substantial research will be needed before "strong" recommendations may be available. These treatment guidelines are intended to *facilitate* clinical decision making in the treatment of AOS. That is, although knowledge gained through clinical research and systematic reviews is a fundamental component of evidence-based practice, it should be integrated with other forms of knowledge such as clinical experience, theoretical rationale, and understanding of patient needs and preferences (Tonelli, 2001).

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REFERENCES

Andrews, G., & Cutler, J. (1974). Stuttering therapy: The relation between changes in symptom level and attitudes. *Journal of Speech and Hearing Disorders, 39,* 312–319.

Articulate Instruments. (2005). www.articulateinstruments.com

Aten, J. L. (1986). Aphasia and severe apraxia of speech: Charting the treatment course. In R. Marshall (Ed.), *Case studies in aphasia rehabilitation* (pp. 119–132). Austin, TX: Pro-Ed.

Austermann, S. N., Maas, E., Robin, D. A., Ballard, K. J., & Schmidt, R. A. (2004, May). *The role of feedback frequency in the treatment of acquired apraxia of speech.* Paper presented at the annual Clinical Aphasiology Conference, Park City, Utah.

Bailey, S. (1983). Blissymbols and aphasia therapy: A case study. In C. Code & D. Muller (Eds.), *Aphasia therapy* (pp. 178–186). London: Edward Arnold.

Barlow, S. M., Finan, D. S., & Park, S. (2004). Sensorimotor entrainment of respiratory and orofacial systems in humans. In B. Massen, R. D. Kent, H. F. M. Peters, P. H. H. M. van Lieshout, & W. Hulstijn (Eds.), *Speech motor control in normal and disordered speech* (pp. 211–224). Oxford: Oxford University Press.

Bose, A., Square, P. A., Schlosser, R., & van Lieshout, P. (2001). Effects of PROMPT therapy on speech motor function in a person with aphasia. *Aphasiology, 15*(8), 767–785.

Brendel, B., Ziegler, W., & Deger, K. (2000). The synchronization paradigm in the treatment of apraxia of speech. *Journal of Neurolinguistics, 13,* 241–327.

Cherney, L. R. (1995). Efficacy of oral reading in the treatment of two patients with chronic Broca's aphasia. *Topics in Stroke Rehabilitation, 2*(1), 57–67.

Code, C., & Gaunt, C. (1986). Treating severe speech and limb apraxia in a case of aphasia. *British Journal of Disorders of Communication, 21*(1), 11–20.

Corbin, M. L. (1951). Group speech therapy for motor aphasia and dysarthria. *Journal of Speech and Hearing Disorders, 16,* 21–34.

Croot, K. (2002). Diagnosis of AOS: Definition and criteria. *Seminars in Speech and Language, 23*(4), 267–279.

Dabul, B., & Bollier, B. (1976). Therapeutic approaches to apraxia. *Journal of Speech and Hearing Disorders, 41,* 268–276.

Deal, J. L., & Florance, C. L. (1978). Modification of the eight-step continuum for treatment of apraxia of speech in adults. *Journal of Speech and Hearing Disorders, 43,* 89–95.

Dowden, P. A., Marshall, R. C., & Tompkins, C. A. (1981). Amer-Ind sign as a communicative facilitator for aphasic and apraxic patients. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 133–140). Minneapolis, MN: BRK.

Dworkin, J. P., & Abkarian, G. G. (1996). Treatment of phonation in a patient with apraxia and dysarthria secondary to severe closed head injury. *Journal of Medical Speech-Language Pathology, 2,* 105–115.

Dworkin, J. P., Abkarian, G. G., & Johns, D. F. (1988). Apraxia of speech: The effectiveness of a treatment regime. *Journal of Speech and Hearing Disorders, 53,* 280–294.

Fawcus, M., & Fawcus, R. (1990). Information transfer in four cases of severe articulatory dyspraxia. *Aphasiology, 4*(2), 207–212.

Florance, C. L., & Deal, J. L. (1977). A treatment protocol for nonverbal stroke patients. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 59–67). Minneapolis, MN: BRK.

Florance, C. L., & Deal, J. L. (1979). Treatment for apraxia of speech: A conversational program. Ohio *Journal of Speech and Hearing,* 184–191.

Florance, C. L., Rabidoux, P. L., & McCauslin, L. S. (1980). An environmental manipulation approach to treating apraxia of speech. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 285–293). Minneapolis, MN: BRK.

Frattali, C., Bayles, K., Beeson, P., Kennedy, M., Wambaugh, J., & Yorkston, K. M. (2003). Development of evidence-based practice guidelines: Committee update. *Journal of Medical Speech-Language Pathology, 11*(3), 9–18.

Freed, D. B., Marshall, R. C., & Frazier, K. E. (1997). Long-term effectiveness of PROMPT treatment in a severely apractic-aphasic speaker. *Aphasiology, 11*(4/5), 365–372.

Golper, L. C., Wertz, R. T., Fratalli, C. M., Yorkston, K. M., Myers, P., Katz, R., et al. (2001). *Evidence-based practice guidelines for the management of communication disorders in neurologically-impaired individuals: Project introduction.* [Online]. Available: http://www.ancds.org

Hadar, U., Twiston-Davies, R., Steiner, T. J., & Rose, F. C. (1984). A psychomotor approach to improving speech modulating suprasegmental control in motor dysphagia and articulatory apraxia. *Advances in Neurology, 42,* 337–351.

Holtzapple, P., & Marshall, N. (1977). The application of multiphonemic articulation therapy with apraxic patients. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 46–58). Minneapolis, MN: BRK.

Howard, D., Patterson, K., Franklin, S., Orchard-Lisle, V., & Morton, J. (1985). The facilitation of picture naming in aphasia. *Cognitive Neuropsychology, 2,* 49–80.

Howard, S., & Varley, R. (1995). Using electropalatography to treat severe acquired apraxia of speech. *European Journal of Disorders of Communication, 30*(2), 246–255.

Kahn, H., Stannard, T., & Skinner, J. (1998). The use of words versus nonwords in the treatment of apraxia

of speech: A case study. *ASHA Division 2 Newsletter, 8*(3), 5–9.

Katz, W. F., Bharadwaj, S. V., & Carstens, B. (1999). Electromagnetic articulography treatment for an adult with Broca's aphasia and apraxia of speech. *Journal of Speech, Language, and Hearing Research, 42*(6), 1355–1366.

Keith, R. L., & Aronson, A. E. (1975). Singing as therapy for apraxia of speech and aphasia: Report of a case. *Brain and Language, 2*, 483–488.

Knock, T. R., Ballard, K. J., Robin, D. A., & Schmidt, R. A. (2000). Influence of order of stimulus presentation on speech motor learning: A principled approach to treatment for apraxia of speech. *Aphasiology, 14*(5/6), 653–668.

Lane, V. W., & Samples, J. M. (1981). Facilitating communiction skills in adult apraxics: Application of Blissymbols in a group setting. *Journal of Communication Disorders, 14,* 157–167.

LaPointe, L. L. (1984). Sequential treatment of split lists: A case report. In J. Rosenbek, M. McNeil, & A. Aronson (Eds.), *Apraxia of speech: Physiology, acoustics, linguistics, management* (pp. 277–286). San Diego: College-Hill Press.

Lasker, J. P., & Bedrosian, J. L. (2001). Promoting acceptance of augmentative and alternative communication by adults with acquired communication disorders. *AAC: Augmentative & Alternative Communication, 17*(3), 141–153.

LogoMetrix. (2005). www.logometrix.org

Lustig, A. P., & Tompkins, C. A. (2002). A written comprehension strategy for a speaker with aphasia and apraxia of speech: Treatment outcomes and social validity. *Aphasiology, 16*(4/5/6), 507–521.

Maas, E., Barlow, J., Robin, D., & Shapiro, L. (2002). Treatment of sound errors in aphasia and apraxia of speech: Effects of phonological complexity. *Aphasiology, 16*(4/5/6), 609–622.

Marcuse, E. K., Shiffman, R. N., Homer, C. J., Lannon, C. M., Harbaugh, N., Hodgson, E. S., & Simpson, L. (2004). Classifying recommendations for clinical practice guidelines. American Academy of Pediatrics policy statement. *Pediatrics, 114*(3), 874–877.

Marshall, R. C., Gandour, J., & Windsor, J. (1988). Selective impairment of phonation: A case study. *Brain and Language, 35,* 313–339.

McHenry, M., & Wilson, R. (1994). The challenge of unintelligible speech following traumatic brain injury. *Brain Injury, 8*(4), 363–375.

McNeil, M. R., Prescott, T. E., & Lemme, M. L. (1976). An application of electromyographic biofeedback to aphasia/apraxia treatment. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 151–171). Minneapolis, MN: BRK.

Merriam-Webster. (2005). Merriam-Webster online dictionary, www.m-w.com.

Odell, K. (2002). Considerations in target selection in apraxia of speech treatment. *Seminars in Speech and Language, 23*(4), 309–323.

Partridge, C., & Johnson, M. (1989). Perceived control of recovery from physical disability: Measurement and prediction. *British Journal of Clinical Psychology, 28,* 53–59.

Rabidoux, P., Florance, C., & McCauslin, L. (1980). The use of a Handi Voice in the treatment of a severely apractic nonverbal patient. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 294–301). Minneapolis, MN: BRK.

Raymer, A. M., Haley, M. A., & Kendall, D. L. (2002). Overgeneralization in treatment for severe apraxia of speech: A case study. *Journal of Medical Speech-Language Pathology, 10*(4), 313–317.

Raymer, A. M., & Thompson, C. K. (1991). Effects of verbal plus gestural treatment in a patient with aphasia and severe apraxia of speech. In T. E. Prescott (Ed.), *Clinical Aphasiology* (Vol. 20; pp. 285–298). Austin, TX: Pro-Ed.

Robey, R. R., & Schultz, M. C. (1998). A model for conducting clinical-outcome research: an adaptation of the standard protocol for use in aphasiology. *Aphasiology, 12*(9), 787–810.

Rogers, M. A.(2001). Treatment research on augmentative and alternative communication for adults with apraxia of speech. *ASHA Division 2 Newsletter, 11*(4), 21–27.

Rosenbek J. C., Collins M., Wertz, R. T. (1976). Intersystemic reorganization for apraxia of speech. Clinical aphasiology conference proceedings. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 255–260). Minneapolis, MN: BRK.

Rosenbek, J. C., Lemme, M. L., Ahern, M. B., Harris, E. H., & Wertz, R. T. (1973). A treatment for apraxia of speech in adults. *Journal of Speech and Hearing Disorders, 38,* 462–472

Rosenberg, M. (1965). *Society and the adolescent self-image.* Princeton, NJ: Princeton University Press.

Rubow, R. T., Rosenbek, J. C., Collins, M. J., & Longstreth, D. (1982). Vibrotactile stimulation for intersystemic reorganization in the treatment of apraxia of speech. *Archives of Physical Medicine Rehabilitation, 63,* 150–153.

Rutschmann, O. T., McCrory, D. C., Matchar, D. B., & the Immunization Panel of the Multiple Sclerosis Council for Clinical Practice Guidelines. (2002). Immunization and MS: A summary of published evidence and recommendations. *Neurology, 59,* 1837–1843.

Sands, E. S., Freeman, F. J., & Harris, K. S. (1978). Progressive changes in articulatory patterns in verbal apraxia: A longitudinal case study. *Brain and Language, 6*(1), 97–105.

Schmidt, R. A., & Lee, T. D.(1999). *Motor control and learning: A behavioral emphasis* (3rd ed.). Champaign, IL: Human Kinetics.

Shane, H. C., & Darley, F. L. (1978). The effect of auditory rhythmic stimulation on articulatory accuracy in apraxia of speech. *Cortex, 14,* 444–450.

Simmons, N. N. (1978). Finger counting as an intersystemic reorganizer in apraxia of speech. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 174–179). Minneapolis, MN: BRK.

Simmons, N. N. (1980). Choice of stimulus modes in treating apraxia of speech: A case study. In R.H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 302–307). Minneapolis, MN: BRK.

Simpson, M. B., & Clark, A. R. (1989). Clinical management of apractic mutism. In P. Square-Storer (Ed.), *Acquired apraxia of speech in aphasic adults* (pp. 241–266). Hove and London: Lawrence Erlbaum.

Skelly, M. (1979). *Amer-Ind gestural code based on universal American Indian hand talk.* New York: Elsevier.

Skelly, M., Schinsky, L., Smith, R. W., & Fust, R. S. (1974). American Indian Sign (AMERIND) as a facilitator of verbalization for the oral verbal apraxic. *Journal of Speech and Hearing Disorders, 39,* 445–456.

Southwood, H. (1987). The use of prolonged speech in the treatment of apraxia of speech. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 277–287). Minneapolis, MN: BRK.

Square, P. A., Chumpelik, D. A., & Adams, S. (1985). Efficacy of the PROMPT system for the treatment of acquired apraxia of speech. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 319–320). Minneapolis, MN: BRK.

Square, P. A., Chumpelik, D. A., Morningstar, D., & Adams, S. (1986). Efficacy of the PROMPT system for the treatment of acquired apraxia of speech: A follow-up investigation. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 221–226). Minneapolis, MN: BRK.

Square, P. A., Martin, R. E., & Bose, A. (2001). The nature and treatment of neuromotor speech disorders in aphasia. In R. Chapey (Ed.), *Language intervention strategies in aphasia and related neurogenic communication disorders* (pp. 847–884). Baltimore: Lippincott, Williams & Wilkins.

Square-Storer, P. A., & Hayden, D. C. (1989). PROMPT treatment. In P. Square-Storer (Ed.), *Acquired apraxia of speech in aphasic adults* (pp. 190–219). Hove and London: Lawrence Erlbaum.

Stevens, E. R. (1989). Multiple input phoneme therapy: An approach to severe apraxia and expressive aphasia. In P. Square-Storer (Ed.), *Acquired apraxia of speech in aphasic adults* (pp. 220–238). Hove and London: Lawrence Erlbaum.

Stevens, E., & Glaser, L. (1983). Multiple input phoneme therapy: An approach to severe apraxia and expressive aphasia. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 148–155). Minneapolis, MN: BRK.

Tjaden, K. (2000). Exploration of a treatment technique for prosodic disturbance following stroke. *Clinical Linguistics and Phonetics, 14*(8), 619–641.

Tonelli, M. R., (2001). The limits of evidence-based medicine. *Respiratory Care, 46*(12), 1435–1441.

Wambaugh, J. L. (2002). A summary of treatments for apraxia of speech and review of replicated approaches. *Seminars in Speech and Language, 23*(4), 293–308.

Wambaugh, J. L. (2004). Stimulus generalization effects of sound production treatment for apraxia of speech. *Journal of Medical Speech Language Pathology, 12*(2), 77–97.

Wambaugh, J. L., Doyle, P. J., Kalinyak, M. M., & West, J. E. (1996). A minimal contrast treatment for apraxia of speech. *Clinical Aphasiology, 24,* 97–108.

Wambaugh, J. L., Duffy, J. R., McNeil, M. R., Robin, D. A., & Rogers, M. A. (2006a). *Treatment guidelines for acquired apraxia of speech: A synthesis and evaluation of the evidence.* Manuscript submitted for publication.

Wambaugh, J. L., Duffy, J. R., McNeil, M. R., Robin, D. A., & Rogers, M. A. (2006b). *Evidence-based guidelines for the management of acquired apraxia of speech: Technical report.* [Online]. Available: http://www.ancds.org

Wambaugh, J. L., Kalinyak-Fliszar, M. M., West, J. E., & Doyle, P. J. (1998). Effects of treatment for sound errors in apraxia of speech and aphasia. *Journal of Speech-Language, Hearing Research, 41,* 725–743.

Wambaugh, J. L., & Martinez, A. L. (2000). Effects of rate and rhythm control treatment on consonant production accuracy in apraxia of speech. *Aphasiology, 14*(8), 851–871.

Wambaugh, J. L., Martinez, A. L., McNeil, M. R., & Rogers, M. A. (1999). Sound production treatment for apraxia of speech: Overgeneralization and maintenance effects. *Aphasiology, 13*(9–11), 821–837.

Wambaugh, J. L., West, J. E., & Doyle, P. J. (1998). Treatment for apraxia of speech: Effects of targeting sound groups. *Aphasiology, 12*(7/8), 731–743.

Warren, R. L. (1977). Response to treatment in patients with apraxia of speech. In R. H. Brookshire (Ed.), *Clinical Aphasiology Conference Proceedings* (pp. 80–90). Minneapolis, MN: BRK.

Wertz, R. T. (1984). Response to treatment in patients with apraxia of speech. In J. Rosenbek, M. McNeil, & A. Aronson (Eds.), *Apraxia of speech: Physiology, acoustics, linguistics, management* (pp. 257–276). San Diego: College-Hill Press.

Wertz, R. T. (1998). A case of aphasia, apraxia of speech, and apraxia of phonation. In N. Helm-Estabrooks & A. L. Holland (Eds.), *Approaches to the treatment of aphasia* (pp. 11–36). San Diego: Singular Publishing Group.

Wertz, R. T., LaPointe, L. L., & Rosenbek, J. C. (1984). *Apraxia of speech in adults: The disorder and its management.* Orlando, FL: Grune & Stratton.

World Health Organization ICF. (2005). http://www3.int/icf/icf/

Yorkston, K. M., & Waugh, P. F. (1989). Use of augmentative communication devices with apractic individuals. In P. Square-Storer (Ed.), *Acquired apraxia of speech in aphasic adults* (pp. 267–283). Hove and London: Lawrence Erlbaum.