Controversy regarding the reality, nature, and treatment of developmental apraxia of speech (DAS) has abounded in the literature. Guyette and Diedrich (1981), in their critical review of DAS, concluded that the diagnostic category for this childhood articulatory prosodic disorder is limited in its usefulness, since implications for the treatment of the disorder do not directly follow from the diagnostic term. Nevertheless, reviews of treatment techniques to date have demonstrated that "traditional" treatment work equally well for children with DAS and children with "functional" articulation disorders. A myriad of treatment regimens have been proposed for DAS children, and, although some result in fair success, empirical evidence to support the theoretical basis of DAS or the reasons for success of various treatment has been lacking (Dabul, 1971; Rosenthal, 1971; Darley et al., 1972; Chappell, 1973; Rosenbek and Wertz 1972; Yoss and Darley, 1974; Macaluso-Haynes, 1978). Furthermore, there has never been a comparative study to determine the effects of one treatment technique over another or to determine why one method may indeed tap the basic nature of this disorder. Guyette and Diedrich (1981) concluded that until differential effects of treatment are established the reality of DAS and its mutual exclusiveness from "functional" articulation disorders will remain controversial areas.

It is the intention of this article both to provide a theoretical framework for DAS and to examine a method of treatment that appears to focus on its basic underlying elements, that is, impaired abilities to organize and produce volitional speech sounds and sequences.

The method to be described is called the PROMPT system (Prompts for Restructuring Oral Muscular Phonetic Targets). The basis of this system will be explored first by defining apraxia as a movement disorder and then by discussing models of speech-motor control and sensory feedback that appear to be stimulated when using this approach. Discussion of how these theories may apply in a develop
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damage. It does add, however, strong testimony to the plasticity of the developing brain.

Application

The PROMPT system is organized to treat DAS as a movement disorder. Considered within its framework are the possible effects of minor lesions in any number of pathways, which may cause disruptions in planning, sequence, or execution of skilled speech movement. It adheres to the premises of Roy, Luria, and Kelso and Tuller that there is a system of heterarchical control and that disruptions in one or many pathways may result in apraxia. In considering the plasticity of the infant brain, it is certainly possible that undamaged areas—given enough of the “right” programming—eventually assume control over the organization of movement. The PROMPT system, therefore, focuses its treatment on the programming aspects of motor control. It handles the production or output of speech by actually imposing a target position or sequence on the child. It does not require the child to organize or control movement by imitation or perceptual comparisons, as do most other treatment methods now in use.

THEORIES OF CENTRAL PROCESSES CONTROLLING SPEECH PRODUCTION

Several theories of how the speech system organizes control of movement have been put forward in the literature. Since it is not the intent of this article to review all of these, only those theories with relevance to the development of the PROMPT system will be discussed.

Lashley (1951) attached a great deal of importance to the theory of space coordinate systems and to the existence of numerous timing mechanisms in the control of the nervous system. He emphasized that within these systems there was a mechanism for organizing output of sequential movement or, in the case of the speech mechanism, control for coarticulation processes within a spatial pattern.

The term “target” was initially put forward by Lindblom (1963) and Stevens and House (1963). As used, it was a summary or descriptive term to designate an endpoint for a phoneme. MacNeilage (1973) elaborated and combined Lashley’s (1951) space-coordinate system, Steven and House’s (1963) target system, and Hebb’s (1949) motor equivalence theory. Hebb’s theory, although initially geared toward the visual-motor system, examined the problem of accounting for the variability of specific muscular responses that could combine to produce all analogous end results. MacNeilage (1973), when organizing the three theories into one coherent idea in support of the target hypotheses, proposed that “what is involved is not specific movements but directions of movement in relation to goals or targets specified within a space co-ordinate system” (p. 424).

The concept of internalized (intraoral) phonetic targets that may be located within a three-dimensional space-coordinate system is important in that it gives the researcher a way of looking at how the speech system organizes itself when different conditions are imposed on it. If phonetic targets are a reality, then the normal system should be able to achieve them by using different muscle sets or feedback systems, and Lashley’s view of “directions of movement in relation to goals or targets...specified within that system” would be confirmed.

Application

Consistent with theories just mentioned, the PROMPT system uses the idea of targets in aiding the child to produce specific phonemes or sequences of movement. Muma (1978) makes reference to “targetness” as the dynamic character of speech articulation and movement. He defines targetness as a “state denoting the dynamic mechanism in which any given articulatory position is momentarily obtained
mental disorder such as DAS will be integrated with the fundamental tenets of the PROMPT system. Some current research findings comparing this method with traditional therapy techniques, the components of the system, and some implications for treatment will follow.

APRAXIA AS A MOVEMENT DISORDER

Jackson (1874) was among the first to consider apraxia as a disorder of volitional movement, or a condition calling upon the "will" or intent of the speaker to encode a purposeful motorspeech sequence. Liep- mann (1905) invoked the Jacksonian principles of volition when he began to evolve his definitions of "ideational" apraxia. He felt that motor aphasia, as it applied to speech production, was a particular form of limb-kinetic apraxia that stemmed from damage to the sensory association zones in the posterotemporal parietal regions. This apraxia affected the glossolabial-pharyngeal apparatus up to and including the laryngeal structures. According to Liepmann, a limb-kinetic apraxia was characterized by a loss of kinesthetic memories or development of (author's supposition) a definite part of the body or an inability "to execute certain combinations of ... movements ... delicate movement" (Head, 1926, p. 97).

Several researchers since Liepmann's time have ascribed to the centre lesion theory, which primarily emphasizes that specific cortical lesions cause a breakdown in motor planning and sequencing. Luria (1973, 1981), for example, viewed any voluntary speech movement as mediated by a complex functional system involving ideation, kinesthetic afferentation, and kinetic organization. Lesions in any one of these areas, he proposed, disrupt the movement for speech in various ways.

Johns and LaPointe (1976), Denny-Brown (1958), Mateer and Kimura (1977), Geschwind (1975), and Brown (1972) have been the major supporters of the theory that lesions to the supramarginal gyrus are the main cause of limb-kinetic or ideational apraxia. These researchers base their theories on numerous case studies and claim that memory for movement is stored in this area, as well as a system that controls the selection and/or execution of movement or transition of movement.

As one reads the massive amount of literature on adult apraxia lesion sites and theories, it becomes exceedingly clear that apraxia may result from damage to the posterior and possibly the anterior regions of the left hemisphere. Luria (1981, 1973), Roy (1978), and Kelso and Tuller (1981) have begun to evolve a slightly different notion of the controlling factors in apraxia. They share the belief that the cerebral cortex may be viewed as a "highly differentiated but interacting system of zones" and that any lesion in this functional system will disturb the other areas or that hierarchical control of the entire system will be disrupted by any break or breaks in the chain. Roy's position (1978), in particular, considers that damage to the frontal or parietooccipital areas may disrupt planning, whereas damage to the premotor and sensorimotor areas may disrupt the execution of action. This action may be disrupted either in terms of sequence of a number of movements or poor control over isolated movement.

It is well known that in developmental disorders such as DAS typically no specific lesion sites are recognizable (see Horwitz this issue of Seminars). Diffuse damage, in which possible "mini"-lesions or subtle "wiring" difficulties exist, may be more the case. Lenneberg (1964) and Sugar (1952) agreed that due to the plasticity of the infant brain, the observable effect of damage is small unless large areas are severely damaged or damage is bilateral.

Electroencephalographic (EEG) findings contribute little to current knowledge and the validity of "soft neurological signs" are not conclusive or necessarily indicative of "diffuse damage." Certainly, not all of the children diagnosed as having DAS have soft signs, and, in the many that do, the symptoms disappear with age. Unfortunately for the researcher, this only perpetuates the debate of possible organic
while passing from one to the next articulatory movement” (p. 111). By using target articulatory movements or states, he argues, the realizations of a given bundle of phonetic features or the phoneme can be obtained.

Aside from being located within a space-coordinate system, it has been proposed that differing levels of sensory feedback would be important for the speech system to achieve target positions. The PROMPT system ensures that feedback is available to the patient by imposing tactile and kinesthetic prompts for the production of each phoneme or sequence. It inherently aids the patient in reaching a target position by enhancing both closed-loop (sensory) and open-loop (motor-planning) control systems.

SENSORY-FEEDBACK MODELS IN NORMAL MOTOR CONTROL

Currently, the most debated models for the neuromotor control of voluntary movement and the ones that have spurred greatest amounts of research are the closed-loop and open-loop systems. The closed-loop model, or CLM, assumes that sensory information occurring as a result of the speech act—such as auditory, tactile, kinesthetic, and proprioceptive—is fed back to a comparator where a discrimination is made as to whether a discrepancy exists between the output and target signals. If a discrepancy does exist, then an error signal is used to correct the speech output signal. One of the main problems with this model is the relatively long latency-response periods needed for corrections. The open-loop, or preprogramming, model does not depend upon sensory feedback for the control and facilitation of speech, and it shows a much faster response time. This system relies upon its ability to preset the effector unit before the input signal reaches it. The main difference, therefore, between the closed- and open-loop models is that all corrections or adjustments of the input signal take place at the effector unit in the open-loop system, whereas in the closed loop they take place at a comparator before it becomes an output signal (Miloch and Noll, 1980).

Although these models indicate totally different positions, as late there has been a shift toward accepting both of them within a single framework. In this framework, the higher levels of the motor nervous system may determine the overall timing and movement toward end positions (open-loop), but the programming of details and actual execution are accomplished through lower level pathways and mechanisms (closed-loop) (Abbs and Kennedy, 1982).

Several types of studies have been designed to assess the importance of these different planning and feedback models in the role of speech production processes. The study types are described, and a summary of the findings in the literature is provided in the following section.

Motor Equivalence Studies

MacNeilage (1970) suggested that speech-motor commands are adjusted to assure that individual articulators reach semi-invariant target positions despite a substantial degree of variability in their starting positions. Findings corroborating this position have appeared in the following speech areas:

1. The upper and lower lip and jaw have been found to move reciprocally in their cooperative contributions to the oral opening (Abbs and Netsell, 1973; Hughes and Abbs, 1976; Watkin and Fromm, 1978).

2. In the inferior and superior dimension, the tongue and jaw have shown the same type of reciprocal relationships (Chuang, Abbs, and Netsell, 1978).

Research of the articulatory structures appears to support the fact that not only do “individual articulators vary in their repetition to repetition contributions toward a particular vocal tract objective, but, individual muscles appear to trade off in their combined contributions as well.” (Abbs
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and Kennedy, 1982, p. 96). Observations in these studies support a hierarchical, multipathway process underlying the programming of speech movements. This motor control provides a basis for incorporating modes of control along a continuum ranging from afferent to efferent pathways while operating both in a programming and a dynamic feedback mode.

Perturbation Studies

These studies have applied unanticipated “loads” to the articulatory structures, usually the upper and lower lip or jaw, while changes in the articulator selected to perform the expected movement are observed. More recently, the focus of these studies has been on the compensatory movements by other structures or muscles that enable the speech system to reach its target position (Smith and Lee, 1972; Folkins and Abbs, 1973, 1975, 1976; Perkell, 1976; Riorden, 1977). In general, these studies have pointed to the ongoing use of afferent and efferent information by the speech system.

Temporal-Structural Alterations of the Speech Mechanism

Temporal-structural studies have tried to address the issue of how afferent information may control multiple speech movements, and two different techniques have been developed.

In the bite-block studies, a bite-block, is placed between the teeth, fixing the jaw, and changes in the reorganization or movement of the tongue and lips are observed (Lindblom and Sundberg, 1971; Lindblom, Lubker, and Gray, 1977; Garrison, 1977, Chuang et al., 1978; Perkell, 1979; Gay and Turvey, 1979). Overall results again have lent support for a multiloop system of control, thus implicating both open- and closed-loop models.

In the second set of studies, the palate is artificially altered by placing a pseudo-palate in the subject’s mouth for observing speech proficiency. In contrast to the bite-block studies, in which the speech adaptation was almost instantaneous and produced few deviant speech patterns, these subjects often required days or weeks of practice to achieve normal proficiency levels (Hamlet, Stone, and McCarty, 1978). In these studies, open-loop, or efference, appeared to be suggested as the principal operating mode. What was not ascertained, however, was to what degree afferent feedback was used to reprogram the cortical structures in attempts to readjust the articulators to the competent production of new speech output.

Oro sensory Anesthetization Studies

These studies focused on blocking sensory-feedback mechanisms, that is, auditory, tactile, kinesthetic, and proprioceptive. Perhaps most important to this discussion are the studies by Putnam and Ringle (1972) and Scott and Ringle (1971) in which orosensory blocks were administered to the trigeminal, mylohyoid, infraorbital, and nasopalatine nerves, thus desensitizing the tongue, lips, teeth, hard palate, velum, and uvula. Although this treatment had minimal effect on overall speech intelligibility, the naturalness of speech was clearly impaired, and errors of the phonemes most likely to be affected by loss of afferent information were noticed. That is, fricatives and affricatives were particularly affected. The most changes were noted in the way the speech apparatus lost its fine control, used more mass movement, bunching, overshooting, and extended duration in order to produce phonetic targets. In all, afferent (closed-loop) feedback was affected and produced errors of fine movement control, although overall programming (efferent control) was not affected, and general speech intelligibility remained. A recent study by Kelso and Tuller (1983) also supported these results.

Evidence from normal motor-control studies continues to suggest that both afferent (closed-loop) and efferent (open-loop) systems are necessary and operate in
speech production. In children with DAS, in whom normal systems have not been established or are in the process of becoming organized, feedback information would seem essential in order to help the preprogramming or open-loop system develop. If articulatory structures are not providing adequate peripheral sensory feedback, it is assumed that the child will have extreme difficulty establishing an oral space-coordinate system. Furthermore, an aberrant sense of correct intraoral targets will develop. Certainly, Rosenbek (1978) has considered apraxia to include a sensory perceptual influence, and Yoss and Darley (1979) have found that errors involving rate, place, voicing, continuancy, and quick repetitive movements for phoneme production or sequences are impaired in children with apraxia.

The PROMPT system imposes control on the articulators by providing tactile and kinesthetic (closed-loop) feedback, while guiding the structures toward sequential, feed-forward (open-loop) programming. The general effect is one of reducing inadequate feedback and providing correct movement sequences in order to help establish "normal" speech-motor production.

THE PROMPT SYSTEM

The PROMPT system was formally organized in 1980. Until that time, it had been a technique used by this author on a trial basis over many years in the treatment of many types of disorders.

Many systems previous to this have suggested a need for facilitating oral-verbal feedback for the misarticulating child. Standard phonetic approaches, such as phonetic placement, have been used for as long as individuals have attempted to modify deviant articulatory patterns. More than 50 years ago, Scripture and Jackson (1927) published A Manual of Exercises for the Correction of Speech Disorders. Their procedure included phonetic placement techniques for speech instruction. It was suggested that mirror work, drawings to show the placement of the articulators, and the use of tongue depressors be used. Obviously, most clinicians still resort to some of these tactics when dealing with misarticulating children.

Another approach that also had its roots in phonetic placement was Stickfield and Younge's (1958) moto-kinesthetic approach. Their system used tactile cues and signals to help the child locate correct placement positions or muscles to be used to achieve those placements. This was the first method to consider movement of speech sequences. Many other techniques have embodied the phonetic placement approach as part of their beginning establishment of the phoneme in isolation.

COMPONENTS

The PROMPT system, as briefly described previously, is a tactile-based treatment method for reshaping individual and connected articulatory phonemes and sequences. The system uses a different prompt for each English phoneme. The prompts are given externally using muscles of the face, under the chin, of the structures associated with voicing and nasality, and of the jaw opening.

Especially crucial to the system is the timing of each prompt imposed by the clinician on the child. This becomes especially important when moving from more static segment productions to transitional and coarticulation processes in phrases and sentences. Duration of the prompts, pressure on specific muscle groups, and tension placed on those muscle groups help to develop afference for the development of appropriate programming. The main focus of the system is to provide feed-forward information to the child so that the preselected sequence is not radically disturbed but guided toward correct target positions and appropriate transitions. The following factors are involved in all of the prompts in their individual and combined use.
Place of Contact

Place of contact specifically denotes the primary target movement or end product to be reached. As explained earlier, a target can be regarded as a specification of a point within an oral space-coordinate system. It can also be defined as a position momentarily obtained while passing from one to the next articulatory movement. In general terms, place of contact refers to place of articulation for a given phonetic target. For example, in the phoneme labial /f/, the upper teeth rest on the lower lip, or for the phoneme alveolar /t/, the tongue tip is placed on the alveolar ridge. Place of contact is important to the clinician for:

1. Broad identification of phoneme categories—bilabials, alveolars, velar, labial, dentals, and so on.
2. For visual checks of appropriately located targets (for example, if a /t/ is interdentalized, it may produce an /θ/; if an /s/ is anteriorized, it produces a lisp).

For these reasons, understanding normal oral structures, normal locations for phonetic sound categories, deviations in structure, and particular compensatory mechanisms is critically important.

Perhaps it should be stated that “targetness” denotes a movement toward an end-point that will result in an acoustically acceptable production of the phoneme selected by the speaker. If this is the case, then place of contact will likely vary to some degree, depending on the contextual constraints and structural deviations of the individual.

The PROMPT system gives locations or end-points to be reached by the articulators and in this sense specifies place orientation. However, one must realize that the prompts, or target positions, encapsulate more than place and manner values, since facilitation of transitions is also achieved. Furthermore, the system accommodates the intravariability of speech production of each child or adult.

Closure

For all vowels and some consonants, closure reflects the degree of jaw openness needed for a primary target movement. In classic terms, closure would refer to jaw height or the position of the jaw and tongue needed to produce phonemes either in isolation or coarticulation. The PROMPT system concerns itself with four different jaw positions. These positions, depicted in Figure 2, are:

1. Neutral resting. In this position the teeth are just touching and the jaw is loose. Most consonant productions are made in this position, especially in running speech. For example, the plosives /p/ and /b/ require no movement from the jaw or tongue and involve the labial structures only. The high vowels /i/, /I/, and /u/ are also examples of a number one closure position.
2. Part open. In this position the jaw is just slightly lowered, in a lax or very relaxed state. Most running speech occurs between numbers one to three closures, with part open, or position
Closure or jaw opening is important in that the tongue follows the jaw, and for production of sounds where the tongue tip is lowered and the dorsum elevated, using an open jaw position can aid the clinician in lifting the rear portion of the tongue. Although, as stated earlier, it was found that normal speakers could produce intelligible speech under bite-block conditions (where the jaw is fixed) by using compensatory structures, the defective or developmental speaker will show even more speech handicap unless the articulators show good range of movement.

Manner

In the PROMPT system, feature differences or sound categories are considered. Each of the prompts gives consideration to the main features of each phoneme class or the positive condition. Referring to Figures 1, 2, and 3, it may be observed that there are individual prompts for voicing and nasal quality that may be used in conjunction with other specific phoneme prompts. These prompts may emphasize such parameters as duration (relative duration of a phonetic movement), continuancy (fixed articulatory posture in which either oral or nasal cavity is open), movement (of articulators throughout sound production), fusion (blend of two target postures—/ts/), lateralization (lateral air movement around the tongue blade), and labialization (secondary closure by lip rounding).

Depending on the nature of the phoneme, certain features will be emphasized. For example, if the phoneme were /k/, the duration, place, and jaw height would be considered. If the phoneme were /s/, the continuancy, facial posture, and tongue tension would be considered (see Figures 1, 2, and 3).

Muscles Used in Specific Phoneme Production

The system continually uses the muscles and muscle groups to effect a given

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Figure 2. Jaw positions for vowel production.
target position. For example, the facial prompts are given on specific locating positions around the orbicularis oris, buccinator, and zygomatic muscles. For the mylohyoid prompts, attention is paid to the differences in muscle tension and combined movements of the various tongue muscles. It is assumed that the clinician will be familiar with underlying anatomical structures. The basis for deciding on a /I/ versus /ɛ/ prompt is the muscle tension given to the mylohyoid with the jaw in a partly open position. Attention to details of tension and differing muscle configurations remains a primary emphasis in the system's construction.

Tension Required in Specific Muscles and Muscle Groups

Tension is a well-established term in describing vowel characteristics. For example, /i/ is described as tense, unrounded, high-front. The phoneme /o/ is described as tense, rounded, high-mid, back, and /u/ as lax, rounded, low-high, back. Tense vowels are described as longer in duration and involving a greater degree of muscular tension. High-mid vowels generally are thought of as having more tension than low vowels.

In consonants, tension is normally not an ascribed feature. Instead, they are described with such terms as high, low, back, rounded, stident. In the PROMPT system, tension of muscle groups is noted in the timing required by the contact to produce the target position. For example, /g/ requires more tension of the same group of muscles than the production of /k/. The timing is also extended for /g/, thus allowing for voicing to be initiated. Tension and timing are variables that significantly affect target phoneme production.

Kelso and Tuller (1983) and Fowler et al. (1980) speak of a “mass/spring” system in functional groups of muscles (such as the tongue) that specifies parameters of mass, stiffness, and damping. The basic parameters of such a system, in order to reach a target position, are stiffness and resting length. Certainly, for phoneme or phonetic targets to be achieved, these factors appear as crucial and signal phoneme differences. In coarticulation or phrase production, these elements often mark (signal) prosodic features that provide access to the identification of phonemes and mark major constituents of utterances or segments.

Transitive Movement of Phonemes in Connected Speech

The PROMPT system is unique in that it allows the clinician to cue or prompt each target or target series at a syllable, word, or phrase level. Prompts may be strung together to produce an overall pattern that closely duplicates that of the articulatory movements to be matched or to move the child through the series at the time of production. In other words, the clinician may prompt for a two-phoneme combination, such as /to/toe/, or a three-phoneme combination, such as /æpl/apple. At a phrase level, the clinician may prompt all,
or key, targets to be reached. For example, in the phrase /a big ball/, the clinician may prompt the initial /a/ and the following consonants and leave the vowel productions alone. Depending on the need of the child, prompts may be given only for specified targets in a sequence.

The ability of the system to provide for transitive movement is especially important in such disorders as DAS in which sequencing of phonemes is seen as the most salient problem. It is usually possible to produce a single phoneme in isolation: it is much more difficult to maintain it when coarticulation influences are present.

Several studies have examined aspects of position and context transfer (Powell and McReynolds, 1969; Weston and Irwin 1971; Zehel et al., 1972; Elbert and McReynolds, 1978). Differences and questions still remain as to why and how transfer occurs and in most cases transfer continues to be thought of as a highly individual process. With the PROMPT system, transfer can be achieved readily by providing many contexts for targets to be practiced. The clinician is not left hoping that what has been achieved in isolation will somehow, with practice, occur at the syllable or word level.

**Timing for Transitive Movement**

Timing is closely tied to transitive movement and stress and is described in depth, both previously and in the following section. Timing is critical to a well-produced, sequential phoneme production at the multiple syllabic word and phrase levels. The clinician using the PROMPT system can alter timing by the duration of the prompt, the overall speed of combined prompts, and by the specific selection of some key prompts over others in a sequence.

**Stress**

Stress, as a general definition, refers to the degree of effort, prominence, or importance given to a part of a phrase or sentence. Stress is usually discussed with respect to syllables because of its influences that extend beyond the initial phoneme target. Acoustically, stress is usually carried by the vowel segment within a syllable and correlates acoustically to fundamental frequency, vowel duration, and relative intensity. In the PROMPT system, stressing for suprasegmentals is possible because the clinician may emphasize vowel durational or intensity differences by marking or choosing to intervene with a prompt at a certain place within the phrase. Speed of utterances as well as various stress markers can be controlled. For example, the clinician may help the child to stress the word /big/ in /big ball/ by introducing a prompt for /b/ in that word or by prompting the final /g/. In either case, the emphasis would fall on the vowel after the consonant or before the consonant and change the stress pattern. This technique is especially important when working on sequencing errors at a phrase level. Since stressing is generally "out of phrase" in the speech of DAS children, simultaneous connection of articulation and prosody is desirable and may be achieved using the PROMPT system.

**Organization of the System**

The following attempts to organize and conceptualize the main components of the PROMPT system. This section differs from the preceding in that it specifically deals with what the clinician needs to pay primary attention with regard to the major areas of focus for each phoneme target.

The headings in Table 1 refer to various aspects of the components just mentioned, that is, jaw height or closure, and to such specifics as finger placement for facial prompts. The mylohyoid category shows the mylohyoid prompt position for each phoneme, when one is used, and mouth contact refers to place of contact. Figures 1, 2, and 3, respectively, visually depict mouth contact positions, jaw height positions, and facial contact positions. Timing for the purposes of this table re-
lates to release or duration factors needed in a single phoneme production, whereas the pressure category is dealing more with the tension component, as described earlier.

Although all factors that play a part in the production of the phoneme target are noted, they are not weighted or organized according to value in this chart. In the PROMPT manual, now in preparation, each phoneme is described in depth and listed according to the components and weighting of each in production. For example:

Prompts for all phonemes will be discussed using the following characteristics as they appear most salient.

### Table 1. Consonant Prompts

<table>
<thead>
<tr>
<th>Facial</th>
<th>Jaw Height</th>
<th>Mylohyoid</th>
<th>Nasal Laryngeal</th>
<th>Mouth Contact</th>
<th>Timing</th>
<th>Pressure (Tension)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>1</td>
<td>9</td>
<td>1,2</td>
<td>Hold</td>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>1</td>
<td></td>
<td>1,2</td>
<td>Fast</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>t</td>
<td>1</td>
<td>A</td>
<td>9</td>
<td>Fast</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>1</td>
<td>A</td>
<td>9</td>
<td>Hold</td>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>k</td>
<td>3</td>
<td>D</td>
<td>12-8</td>
<td>Fast</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>3</td>
<td>D</td>
<td>12-8</td>
<td>Hold</td>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>2</td>
<td>Move C to A</td>
<td>11-10-9</td>
<td>Hold</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>1-2 if mylohyoid prompt does not work</td>
<td>D crooked finger</td>
<td>12-8</td>
<td>Hold</td>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>5</td>
<td></td>
<td>2,3</td>
<td>Hold</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>v</td>
<td>5</td>
<td></td>
<td>2,3</td>
<td>Hold</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>θ</td>
<td>1,2</td>
<td>B</td>
<td>9,3-4</td>
<td>Hold</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>s</td>
<td>2</td>
<td>B</td>
<td>9</td>
<td>Hold</td>
<td>Slight</td>
<td></td>
</tr>
<tr>
<td>z</td>
<td>6,7 press in forward</td>
<td>1</td>
<td>A</td>
<td>3-4,9-4</td>
<td>Hold</td>
<td>Moderate</td>
</tr>
<tr>
<td>f</td>
<td>6,7 press in forward</td>
<td>1</td>
<td>A-C</td>
<td>10, 6...7</td>
<td>Hold</td>
<td>Moderate</td>
</tr>
<tr>
<td>s</td>
<td>6,7 push out back</td>
<td>1</td>
<td>A-C</td>
<td>10, 6...7</td>
<td>Hold</td>
<td>Moderate</td>
</tr>
<tr>
<td>m</td>
<td>8</td>
<td></td>
<td>8</td>
<td>Hold</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>8</td>
<td>A</td>
<td>8</td>
<td>Hold</td>
<td>Firm</td>
<td></td>
</tr>
<tr>
<td>h</td>
<td>Blow air on each other's hands</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**The Vowels**

When air flows freely past the vibrating vocal folds and through the oral cavity, unobstructed by the articulators, the resulting phoneme is a vowel (Fig. 4). Depending on the amount of jaw opening and the
pressure are important components. These are indicated by pressure values or timing variables. If facial prompts are needed for a vowel, they are indicated.

Diphthongs are listed as combinations of two vowels and should be produced as such when the clinician is trying to elicit them from the patient. The most difficult aspect with diphthongs and affricatives /ts/ and /dz/ is the two-phoneme combination. This requires excellent timing and precision by the clinician, but, with practice, brings excellent results for usually difficult targets.

THE SYSTEM: PROBLEMS AND SOLUTIONS

In testing the PROMPT system with DAS children, traditional audiovisual therapy techniques and the PROMPT system were compared (Chumpelik and Sherman, in preparation). Results indicated that for more difficult targets,—some vowels, consonants with tension, and timing factors—the PROMPT system was the only way to produce change. It also indicated that subjects trained on phonemes using the PROMPT system transferred these phonemes into real words that were not trained. Certainly, from this author's experience and from the results of the research, the PROMPT system appeared to be tapping and perhaps reprogramming various aspects of the motor program needed for a specific phonetic target. It also suggested that programming occurring in a sequence was even more powerful in producing organizational change.

As shown with numerous children, and validated by the research, the PROMPT system works and in some cases may be the only method that will produce change in a target production. However, as with any complex system, problems can occur for the clinician while trying to learn to use it. Following are some of the areas in which difficulties may occur.

COMFORT LEVEL OF THE CLINICIAN

The system requires that the clinician touch the face of the patient and, at times, control the head position with the hands. It demands that the clinician feel comfort-
### TABLE 2. Vowel Prompts

<table>
<thead>
<tr>
<th>Jaw Height</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SP C</td>
<td>F C</td>
<td>[u]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[i]</td>
<td>[I]</td>
<td>Q</td>
<td>facial 1.2 push out</td>
</tr>
<tr>
<td>2</td>
<td>SP C</td>
<td></td>
<td></td>
<td>whole hand around obicularis oris muscle C [ɔ]</td>
</tr>
<tr>
<td></td>
<td>[ei]</td>
<td></td>
<td></td>
<td>facial 1.2</td>
</tr>
<tr>
<td>3</td>
<td>SP Q</td>
<td>SP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[e]</td>
<td>[ə]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SP C</td>
<td>SP C</td>
<td>[æ]</td>
<td>[ɑ]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SP: slight pressure; F: firm pressure; Q: quick pressure release; C: constant pressure; /ai/: prompt for /a/ transition to /i/ or jaw position for /a/; /ai/: prompt for /a/ to /w/ or jaw position for /a/ and facial position for /ai/; /ai/: prompt for /o/ transition to /i/; /ai/: prompt for /e/ transition to /i/; jaw prompt for /e/; facial prompt for /i/.

able touching another human being and imposing a certain set of movement patterns on him. Often the clinician feels awkward touching the child—using what must occasionally be firm pressure for a mylohyoid prompt—or feels insecure in coordinating two or more prompts. The tendency is for the clinician to think this is an “easy” task and yet feel uncomfortable when actually doing it. This feeling of discomfort is ultimately transferred to the patient and then either the process is disrupted or avoiding behaviors may result. The effect of this is to disrupt the clinician-patient trust, and the usually secure clinician may become insecure.

When the clinician feels comfortable and at ease, the patient does too. In the numerous children I have seen, not one has ever seriously objected to being touched. In fact, most children and adults enjoy the sensation and will begin to prompt themselves or others.

### ANALYZING COMPONENTS OR CHOOSING THE CORRECT PROGRAM

Each child or adult uses differing strategies to reach a target position or sequence a series of targets. This means that the clinician must:

1. Continually analyse the components of each target and place individual attention on those components that are not allowing for correct production to be achieved
2. Decide what components or prompts should be used (one or a combination) that will produce the desired motor pattern
3. Then, reanalyse this strategy to assess whether the correct results have been achieved.

These series of steps must happen almost instantaneously, which means the clinician must understand neurophysiological
processes operating for the child in the target production, the anatomical features of articulation, and the prompts for each component.

In most patients, certain components of a phoneme target would be emphasized first. However, in other patients, components that usually do not require attention, such as voicing or manner, would be of most importance. For these reasons, it is crucial that the clinician understand how phoneme targets are constructed and how they "feel" in their own articulators before they begin to work with children or adults with disordered production. If a clinician does not understand this, problems and frustration may compound the difficulties that the patient is already experiencing.

WORKING AT THE WORD OR PHRASE LEVEL

When working at the word or phrase level, the clinician's sense of timing and stressing must be very precise and fairly accurate with regard to the prompt placement position (although not nearly as accurate as when working on a specific phoneme target). If this does not happen, then the sequence being attempted will be disrupted and result in more confusion. Obviously, the intent of the system is to prevent program errors, not to create them.

At the word or phrase level, not every phoneme will need to be prompted. Depending on individual needs, it may be that only initial and final consonants in a sequence need prompts or a specific distorted/ substituted phoneme. Sometimes jaw aperture and facial muscles need attention. Whatever the need, the clinician must be flexible and able to anticipate when to enter the sequence without totally disrupting it.

SUMMARY

This article is an attempt to outline a treatment method called the PROMPT system. This system has been used successfully with children with DAS and other speech-disordered groups whose production or sequencing of phonetic targets is impaired or delayed.

The neurological basis of the PROMPT system was explored in terms of normal movement and feedback studies. It was proposed that the system uses a feedforward method that combines both elements of open- and closed-loop models. This supposition that both systems are operative in normal speech production has been supported by current literature, which suggests that "normal motor control appears to be the result of delicate interactions among a hierarchy of cascaded neural pathways operating both peripherally and centrally" (Abbs and Kennedy, 1982).

When discussing the possible reasons why the PROMPT system works, it was proposed that, in children with DAS, the system may help provide the lacking and essential kinesthetic feedback (closed-loop) while providing the feed-forward or sequential information (open-loop) that the system needs for transforming conscious motor control into automatic sequences. Certainly, the literature supports what the PROMPT system attempts to provide: a treatment approach that combines the elements of neurological or sensory feedback model with a motor-learning approach.

The term "phonetic target," as used in this article, also comes from a theoretical basis and proposes that specific movements are not as important as patterning of those movements to reach a target position. To use a gross analogy, we might say that automobiles in different locations can still be driven to the same place. Hebb (1949), Lashley (1951), Muma (1978), Abbs and Kennedy (1982), and others speak of the "equivalence of the system" to reach an invariant end-point, no matter from what position the movement was initiated or regardless of what sets of muscles must be used. The PROMPT system embodies this theory in practice. It cues or prompts the major end-points (targets) to be reached and allows the motor system to use any
means it needs during transition to reach these end-points. In other words, it specifies the target positions to be obtained while helping the child reach these positions.

The PROMPT system is a useful tool for the clinician in that it enables the reduction of phonetic errors (Chumpelik and Sherman, 1983) and helps to reprogram phonetic/phonemic combinations (words) under almost any condition. This system has been shown to work in controlled, behavioral conditions, or in unstructured group situations in which language is also a treatment focus. It is a flexible system that, once learned, allows the clinician to work from the single phoneme level to a conversational or sentence level without any stress or noticeable change to the patient.

Perhaps the most important factor in any technique aside from effectiveness, is how the patient reacts to it. Positive feedback occurs from such events as the look on children’s faces upon realizing that you can really help them, the fact that they take their own hands to their faces and try then to help themselves, and the anecdotal stories from parents who say they use it at home on themselves and all the siblings to “help them talk.” When this type of reaction is seen, it reinforces the reasons why research and understanding of the process of speech production are necessary.

The PROMPT system is a method that works if the clinician who uses it understands its simplicity and complexity. In the final analysis, the PROMPT system confirms the obvious—that any well-constructed system used with selectivity and sensitivity is an asset to both the clinician and the patient.

REFERENCES


Geshwind, N.: The apraxias: Neural mecha-


