Examination of Motor Speech Disorders

*"One of the most important parts of a scientist's work
is the discovery of patterns in data."[5]*

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CHAPTER OUTLINE

Identifying a speech problem as neurologic and then localizing it within the nervous system is similar to a neurologist's efforts to localize disease and establish a neurologic diagnosis. The differences between the two enterprises are that speech may be only one of a number of neurologic problems, and that speech diagnosis is usually not diagnostic of specific neurologic disease. But these differences sometimes blur. Speech difficulty is sometimes the presenting complaint and the only detectable neurologic abnormality, and its diagnosis may permit localization and a tentative disease diagnosis. Speech examination is thus an important component of many neurologic examinations.

This chapter discusses the examination of speech in people with suspected motor speech disorders (MSDs). It is not the intent here to discuss the interpretation or application of examination findings to diagnosis or management, beyond some illustrative examples. The relationship between examination results and specific speech diagnoses is addressed in each chapter on specific MSDs (Chapters 4 to 14) and in Chapter 15 (Differential Diagnosis). The relationship of examination results to management is addressed in Chapter 16.

PURPOSES OF MOTOR SPEECH EXAMINATION

The motor speech examination reflects several goals and activities that are relevant to diagnosis. Different goals are often pursued simultaneously, but they can be isolated and sequenced in a way that helps organize the activities that make up the examination. These goals include description, establishing diagnostic possibilities, establishing a diagnosis, establishing implications for localization and disease diagnosis, and specifying severity.

Description

Description characterizes the features of speech and structures and functions related to speech. It represents the data upon which diagnostic and treatment decisions are made. In some cases the diagnostic process ends with description, because findings

cannot establish a diagnosis or even a limited list of diagnostic possibilities. The bases for description derive from the patient's history and description of the problem, the oral mechanism examination, the perceptual characteristics of speech and results of standard clinical tests, and instrumental analyses of speech.

Once speech is described, the clinician asks if the characteristics are normal or abnormal. This is the first step in diagnosis, and an important one. If all aspects of speech are within the range of normal, the diagnosis is normal speech. If some aspects of speech are abnormal, then their meaning must be interpreted. *The process of narrowing diagnostic possibilities and arriving at a specific diagnosis is known as differential diagnosis.*

Establishing Diagnostic Possibilities

If speech is abnormal, then a list of diagnostic possibilities can be generated. Because the emphasis here is on MSDs, the list can grow out of answers to questions such as the following:

1. Is the problem neurologic?
2. If the problem is not neurologic, is it nonetheless organic? For example, is it due to dental or occlusal abnormality, mass lesion of the larynx, or is it psychogenic?
3. If the problem is or is not neurologic, is it recently acquired or longstanding? For example, might it reflect unresolved developmental stuttering, articulation disorder, or language disability?
4. If the problem is neurologic, is it an MSD or another neurologic disorder that is affecting verbal expression (e.g., aphasia, dementia, akinetic mutism)? If an MSD is present, is it a dysarthria or apraxia of speech?
5. If dysarthria is present, what is its type?

Establishing a Diagnosis

Once all reasonable diagnostic possibilities have been recognized, a single diagnosis may emerge or, at the least, the possibilities may be ordered from most to least likely. For example, concluding that speech is not normal, that it is not psychogenic in origin, and that it is a dysarthria but of undetermined type, is of diagnostic value. It implies the existence of an organic process and places the lesion within motor components of the nervous system. If it also can be concluded that the dysarthria is not flaccid, then the lesion is further localized to the central and not the peripheral nervous system, and certain neurologic diagnoses can be eliminated or considered unlikely. If the characteristics of the disorder are

unambiguous and compatible with only a single diagnosis, then a single speech diagnosis can be given along with its implications for localization.

Establishing Implications for Localization and Disease Diagnosis

When an MSD is identified, it is appropriate to address explicitly its implications for neurologic localization, especially if the referral source is unfamiliar with the method of classification. For example, if spastic dysarthria is the diagnosis, it is appropriate to state that the disorder is usually associated with bilateral involvement of upper motor neuron (UMN) pathways. If a tentative neurologic diagnosis has already been made, it is appropriate to address the compatibility of the speech diagnosis with it. For example, if the working neurologic diagnosis is Parkinson's disease but the patient has a mixed spastic-ataxic dysarthria, it is important to report that this mixed dysarthria is not compatible with Parkinson's disease. Finally, if neurologic diagnosis is uncertain or if speech is the only sign of disease, it is appropriate to identify possible diagnoses if the MSD is "classically" tied to them. For example, a flaccid dysarthria that emerges only with speech stress testing and recovers with rest has a very strong association with myasthenia gravis.

Specifying Severity

The severity of a MSD should always be estimated. This estimate is important for at least three reasons: (1) subjective or objective measures of severity can be matched against the patient's complaints; gross mismatches between patient and clinician judgment may introduce the possibility of psychogenic contributions, poor insight, or limited concern about speech on the patient's part; (2) it influences prognosis and management decision making; (3) severity estimates at the time of initial examination represent baseline data against which future changes can be compared.

Specifying severity is actually part of the descriptive process. It is highlighted here because of its relevance to estimating functional limitations and disability imposed by the MSD,[50] as opposed to determining the presence of impairment, which is more relevant to diagnosis. Limitations and disability are more relevant to decisions about management than diagnosis.

Once severity is established, it is appropriate to address the implications of the findings for prognosis and management. These are considered in Chapters 16 to 20.

GENERAL GUIDELINES FOR EXAMINATION

The motor speech examination has three essential procedural components: (1) history, (2) identification of salient speech features, and (3) identification of confirmatory signs. With this information, a diagnosis is made, recommendations formulated, and results communicated to the patient, referring professional, and others.

History

An anonymous sage has said that 90% of neurologic diagnosis depends on the patient's history.[38] A wise neurology colleague of the author has said that most clinical neurologic diagnoses are based on speech, either its content or its manner of expression. It would be difficult to argue that the spoken history provided by the patient is less important to motor speech evaluation and diagnosis.

Experienced clinicians often reach a diagnosis by the time greetings and amenities have been exchanged and a history obtained. Subsequent formal examination confirms, documents, refines, and sometimes revises the diagnosis. The history reveals the time course of complaints and the patient's observations about the disorder. It also puts contextual speech on display when anxiety is generally less than during formal examination; when physical effort, task comprehension, and cooperation are not essential; and when the patient may not feel his or her speech is the subject of scrutiny.

Salient Features

Salient features are those that contribute most directly and influentially to diagnosis. They include deviant speech characteristics and their presumed neuromuscular substrates. In 1975 Darley, Aronson, and Brown (DAB) discussed six salient neuromuscular features that influence speech production. They form a useful framework for integrating observations made during examination. They include strength, speed of movement, range of movement, steadiness, tone, and accuracy. Abnormalities associated with these features are summarized in Table 3-1.

Strength

Muscles have sufficient strength to perform their normal functions, plus a reserve of excess strength. Reserve strength permits contraction over time without excessive fatigue, as well as contraction against resistance.

When a muscle is weak, it cannot contract to a desired level, sometimes even for brief periods. It

table 3-1	Salient neuromuscular features of speech and associated abnormalities commonly encountered in motor speech disorders
Feature	**Abnormality Associated with Motor Speech Disorders**
Strength	Reduced, usually consistently but sometimes progressively
Speed	Reduced or variable (increased only in hypokinetic dysarthria)
Range	Reduced or variable (predominantly excessive only in hyperkinetic dysarthrias)
Steadiness	Unsteady, either rhythmic or arrhythmic
Tone	Increased, decreased, or variable
Accuracy	Inaccurate, either consistently or inconsistently

may fatigue more rapidly than normal. Sometimes a desired level of contraction can be obtained, but ability to sustain it decreases dramatically after a short time.

Muscle weakness can affect all three of the major speech valves (laryngeal, velopharyngeal, and articulatory), and it can be apparent in all components of speech production (respiration, phonation, resonance, articulation, and prosody). Weakness is most apparent and dramatic in lower motor neuron (LMN) or final common pathway (FCP) lesions and, therefore, in flaccid dysarthrias. Consequences of it can be inferred from perceptual and acoustic analyses, observed visually at rest and during speech, detected during oral mechanism examination, or measured physiologically.

Speed

Movements during speech are rapid, especially the laryngeal, velopharyngeal, and articulatory movements that valve expired air to produce the approximately 14 phonemes per second that characterize conversational speech. These quick, unsustained, and discrete movements are known as *phasic movements.* They can occur as single contractions or repetitively. They begin promptly, reach targets quickly, and relax rapidly. Phasic speech movements are mediated primarily through direct activation UMN pathway input to alpha motor neurons (see Chapter 2).

Excessive speed is uncommon in MSDs, although it may occur in hypokinetic dysarthria. Excessive speech rate in people with dysarthria is nearly always also associated with decreased range of motion.

Slow movements are common in MSDs. Movements may be slow to start, slow in their course, or

slow to stop or relax. Single as well as repetitive movements may be slow.

Reduced speed can occur at all major speech valves and during all components of speech production. Slow movement strongly affects the prosodic features of speech because normal prosody is so dependent on quick muscular adjustments that influence rate of syllable production and pitch and loudness variability. The effects of reduced speed are most apparent in spastic dysarthria but also are present in other dysarthria types. The effects of altered speed can be perceived in speech, visibly apparent during speech and oral mechanism examination, and measured physiologically and acoustically.

Range

The distance traveled by speech structures is quite precise for single and repetitive movements. Variation in the range of repetitive movements is normally present but usually small.

Consistent but inappropriately excessive range of motion during voluntary speech is not common in neurologic disease. In contrast, decreased range is common and may occur in the context of slow, normal, or excessively rapid rate. For example, hypokinetic dysarthria is often associated with decreased range of motion and, sometimes, excessively rapid rate. In other instances, range may be variable and unpredictable. Abnormal variability in range is common in ataxic and hyperkinetic dysarthrias.

Abnormalities in range of motion often have a major influence on the prosodic features of speech, sometimes resulting in restricted or excessive prosodic variations. Such abnormalities can occur at all of the major speech valves and during all components of speech production. They can be inferred from acoustic and perceptual analyses of speech, visible during speech and nonspeech movements of the articulators, and measured physiologically.

Steadiness

At rest, there is a measurable 8 to 12 Hz oscillation of the body musculature. During normal movement there are usually no visible interruptions or oscillations of body parts, but oscillation amplitude sometimes increases to visibly detectable levels in healthy people. This visible *physiologic tremor* can occur in extreme fatigue, under emotional stress, or during shivering.

When motor steadiness breaks down in neurologic disease, the results can be broadly categorized as *involuntary movements* or *hyperkinesias. Tremor* is the most common involuntary movement. It consists of repetitive, relatively rhythmic oscillations of a body part, generally ranging in frequency from 3 to 12 Hz. It may occur at rest *(resting tremor),* when a structure is maintained against gravity *(postural tremor),* during movement *(action tremor),* or toward the end of a movement *(terminal tremor).*

Mild tremor may not have any perceptible effect on speech characteristics dependent on respiration, resonance, or articulation. It commonly affects phonation and, when severe, it can affect prosody; its effects are most easily perceived during sustained vowel production. The effects of tremor on speech may be heard or seen during speech, may be seen during oral mechanism examination, and can be measured physiologically and acoustically.

Another major category of involuntary movement consists of random, unpredictable, adventitious movements that may vary in their speed, duration, and amplitude. These abnormal movements include *dystonia, dyskinesia, chorea,* and *athetosis.* They may be severe enough to interrupt or alter the direction of intended movement. They may be present at rest, during sustained postures, or during movement. They can affect movement at all of the major speech valves and all components of speech production. They can affect accuracy and often alter prosody. They are the primary source of abnormal speech in hyperkinetic dysarthrias. The effects of unpredictable hyperkinesias can be perceived during speech, seen during speech and oral mechanism examination, measured physiologically, and inferred from acoustic measurements.

Tone

Muscle tone is discussed in Chapter 2. The gamma loop and indirect activation pathway are crucial for proper maintenance of tone, which creates a stable framework upon which rapid voluntary movements can be superimposed.

In neurologic disease, muscle tone may be excessive or reduced. It may fluctuate slowly or rapidly in a regular or unpredictable fashion. Alterations in tone may occur at all speech valves and during all components of speech production. Abnormal tone is associated with flaccid dysarthrias when consistently reduced, with spastic or hypokinetic dysarthria when consistently increased, and with hyperkinetic dysarthrias when variable. The effects of abnormal tone can be inferred from perceptual speech characteristics, seen during speech and oral mechanism examination, measured physiologically, and inferred from acoustic measurements.

Accuracy

Individual, repetitive, complex sound sequences are normally executed with enough precision to ensure intelligible and efficient transmission of linguistic and emotional meaning. They result from regulation of tone, strength, speed, range, steadiness, and timing of muscle activity. From this standpoint, accuracy is the outcome of well-timed and coordinated activities of all the other neuromuscular features. If strength, speed, range, steadiness, and tone have been properly regulated, speech movements will be accurate. If speech contains inaccuracies and neuromuscular performance is normal, it is possible that the linguistic plan or ideational content is defective, placing the source of the problem outside of the motor system; an alternative explanation is that the problem lies in the planning or programming of movements and not in neuromuscular execution.

Inaccurate movements can result in various speech errors. For example, if force and range of motion are excessive, structures may overshoot targets. If force and range of motion are decreased, target undershooting may occur. If timing is poor, the direction and smoothness of movements may be faulty, and the rhythm of repetitive movements may be maintained poorly.

Inaccurate movements resulting from constantly present defects of strength, speed, range, and tone may result in predictable degrees of articulatory imprecision or other speech abnormalities. If the source of inaccuracy lies in timing or in unpredictable variations in other neuromuscular components, errors may be unpredictable, random, or transient.

Inaccurate movements may occur at all of the major speech valves and at all levels of speech production but are generally perceived most easily in articulation and prosody. Inaccuracy can occur in all dysarthrias, but when it is the result of inadequate timing or coordination, it is usually associated with ataxic dysarthria or apraxia of speech. When associated with random or unpredictable involuntary variations in movement, it often reflects hyperkinetic dysarthria.

It should be apparent that the salient neuromuscular features of movement interact and influence each other. For example, reduced strength is usually associated with reduced tone, range of motion, accuracy, and sometimes steadiness. Increased or variable tone is usually associated with reduced or variable speed, range of motion, steadiness, and accuracy. Reduced range of motion is associated with variations in speed, tone, and accuracy. *It is rare that only a single abnormal neuromuscular feature is present in someone with dysarthria.*

Confirmatory Signs

Confirmatory signs are additional clues about the location of pathology in the nervous system. In the context of speech examination, they are signs other than deviant speech characteristics and the salient neuromuscular features that characterize them that help support the speech diagnosis or increase confidence in it. *MSD diagnosis does not require that confirmatory signs be present.* Therefore observations of a nonspeech nature, even if of the speech muscles, must be considered circumstantial (confirmatory) evidence and not salient. Nonetheless, they can be helpful in establishing a diagnosis.

Confirmatory signs can be manifest in speech or nonspeech muscles. Examples of confirmatory signs within the speech system are atrophy, reduced tone, fasciculations, poorly inhibited laughter or crying, reduced normal reflexes or the presence of pathologic reflexes, and the strength of the cough. It is important to keep in mind that such signs are not diagnostic of MSDs. For example, lingual fasciculations, without any perceivable impairment of lingual articulation, would not warrant a diagnosis of dysarthria. It might reflect a lesion on nerve XII and require further investigation, but a diagnosis of dysarthria would require the presence of a perceptible *speech* deficit.

Confirmatory signs from the nonspeech motor system come from observations of gait, muscle stretch reflexes, superficial and pathologic reflexes, hyperactive limb reflexes, limb atrophy and fasciculations, difficulty initiating limb movements, and so on. They also include observations of strength, speed, accuracy, tone, steadiness, and range of movements in nonspeech muscles.

Confirmatory signs are discussed within each chapter on the specific dysarthrias and apraxia of speech and also briefly during the following overview of the motor speech examination.

Interpretation of Findings—Diagnosis

Once the history and salient speech features and confirmatory signs have been established, they are integrated to formulate an impression about their meaning. This constitutes diagnosis.

No examination is complete without an attempt to establish the meaning of its findings.* It is reasonable to state as principle that *when the results of an examination cannot go beyond description, the reasons why should be stated explicitly.* The absence of a diagnostic interpretation represents an omission of potentially valuable medical information and can

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*Terms used to introduce diagnostic statements vary in clinical practice, but headings most often include the words *diagnosis, impression,* or *conclusion.* The term *summary* is not an appropriate heading, because the intent is to provide an interpretation of findings, not a brief restatement of them.

convey an impression that although a patient has been assessed, perhaps thoroughly, the results have been neither interpreted nor understood. This can lead to an interpretation by referral sources that speech-language pathology does not contribute to the localization or understanding of speech, language, and communication disorders.

The manner in which diagnostic statements are expressed is influenced by the examination findings plus the intended purposes of the evaluation (e.g., to provide an opinion about the nature of the speech deficit to a neurologist who is uncertain about the neurologic diagnosis; to determine the nature and severity of an MSD for the purpose of management planning). The strength or certainty of diagnostic statements can vary considerably. In some cases, findings may be so ambiguous that they justify only a statement that the diagnosis is uncertain. In others, they may justify a formulation of diagnostic possibilities, perhaps in order from most to least likely. In still others, they may permit a statement about what the disorder is not. And some permit a confidently stated, unambiguous diagnosis. Finally, findings sometimes—perhaps often—lead to a combination of some of the preceding possibilities, such as "the patient has an unambiguous spastic dysarthria, possibly with an accompanying ataxic component. There is no evidence of apraxia of speech." The process of differential diagnosis is discussed in detail in Chapter 15.

▩ THE MOTOR SPEECH EXAMINATION

The motor speech examination can be divided into four parts: (1) history; (2) examination of the oral mechanism during nonspeech activities; (3) assessment of perceptual speech characteristics; and (4) assessment of intelligibility, comprehensibility, and efficiency. Instrumental analyses using acoustic, physiologic, or visual imaging methods may also be part of the clinical examination, but in general, they are not essential. Their use during various portions of the examination is noted when appropriate.

History

The history provides basic information about the onset and course of the problem, the patient's awareness of impairment, and the degree to which the problem limits basic activities or reduces participation in various aspects of life. The spoken history also puts on display the salient features, confirmatory signs, and severity of the problem.

No two histories are the same, and the specific questions that elicit histories will vary considerably. Factors affecting how history taking is approached include patients' cognitive ability and personality,

whether or not they perceive a problem, what has already been established by other professionals, and the severity of the speech deficit. If patients have cognitive limitations, significantly reduced intelligibility, or an inadequate augmentative means of communication, or if they do not perceive a speech deficit, then the history from them may be limited. If the etiology and time course are already known, they need not be pursued beyond confirmation. The history sometimes must be provided or supplemented by someone who knows the patient well. History taking should usually be controlled by the clinician and not the patient, with questions and their sequence strongly influenced by the facts provided by the patient and by their manner of doing so.

The format of history taking often includes the following.

Introduction and Goal Setting

Once basic amenities have been exchanged, the examination can often begin with a simple but important question, *"Why are you here?"* Some representative responses include "to find out what's wrong with me," "to find out what's wrong with my speech," "to find out if you can help me with my speech," "because my doctor told me to come here," "there's nothing wrong with me," and "I don't know why they brought me here!" The answers are an index of patients' orientation, awareness, and concern about their speech; the priority they place on their speech versus other aspects of their illness; the relative importance to them of diagnosis versus management; their ability to provide a history; the depth and manner in which the history will have to be taken; and the actual severity of the speech disorder. This introduction also allows the clinician to inform the patient about the purposes and procedures of examination and its place in their overall evaluation and management.

Basic Data

Age, education, occupation, and marital and family status should be noted. It is important to establish if there was a history of childhood speech, language or hearing deficit, if treatment for those problems was necessary, and if they had resolved before the current illness began. This is essential when abnormalities are inconsistent with other current medical findings but could be longstanding or developmental in nature. The most common longstanding speech deficits encountered in adults with suspected neurologic disease are persisting developmental articulation errors, articulatory distortions associated with dental or occlusal abnormalities, and developmental stuttering.

Onset and Course

Information about the onset and course of the speech deficit is useful to neurologic diagnosis, prognosis, and management decisions. It also reveals something about the patient's perception of the problem. Relevant questions include the following:

- Do you have any difficulty with your speech? If not, has anyone else commented on a change in your speech?
- When did the speech problem begin? Did it begin suddenly or gradually? Who noticed it first, you or someone else?
- Did you develop any other difficulties when your speech problem began? Were other problems present before the speech problem began? Did other problems develop after the speech problem began?
- Has the speech problem changed? Better, worse, stable, fluctuating?
- Has your speech ever returned to normal? If so, when and for how long?
- Are you taking any medications that affect your speech in a positive or negative way? Are there any other factors that predictably affect your speech (e.g., time of day, stress, fatigue, environment)?

Associated Deficits

Questions about associated deficits that may represent confirmatory symptoms include the following:

- Have you had any difficulty with chewing? Drooling?
- Is it difficult to move food around in your mouth? Why?
- Does food get stuck in your cheeks or on the roof of your mouth? Do you have to remove it with your finger or a utensil?
- Do you have trouble moving food back in your mouth to get a swallow started?
- Do you have trouble with swallowing? Food or liquid? Do you have trouble getting a swallow started? Do you lose food or liquid out of your mouth? Does food or liquid ever go into or out of your nose when you swallow? Does food or liquid go down before you start to swallow and cause coughing or choking? Do you gag or choke when swallowing? Do you choke or cough after completing a swallow? Have you had to modify your diet because of these problems? Have you lost weight?
- Have you had any change in your emotional expression? Do you cry or laugh more easily or less easily than in the past?

Patient's Perception of Deficit

It is important to establish the patient's perception of the problem. This can provide useful confirmatory information.

- What was your speech like when the problem began? Did anything *feel* differently when you spoke?
- Have you noticed any change in the appearance or feeling in your face or mouth?
- Describe your current speech difficulty. How does it sound to you? Is it faster or slower? Louder or quieter? Less precise? Is speaking effortful? If 100% represents your speech before the problem began, where is it now?

Consequences of the Disorder

The following questions address some of the functional consequences of MSDs:

- Do people ever have trouble understanding you? If so, when? What do they or you do if that happens?
- Have you altered any of your work or social activities because of your speech? How? Does your speech prevent you from doing anything? If so, what?

Management

Information about what the patient and others (including professionals) have done to manage the speech disorder is useful for determining prognosis and future management recommendations.

- What have you done to compensate for your speech difficulty? Have you had any help for your speech? If so, when? For how long? What was done? Did it help?
- Do you think you need help with your speech now?

Awareness of Diagnosis and Prognosis

It is important to know what the patient understands about his or her medical diagnosis and prognosis because it influences the manner and depth to which the speech diagnosis and management issues should be discussed. For example, patients who are in the process of evaluation to determine the nature of their disease, or who have just received a diagnosis with a poor prognosis, may be neither interested nor emotionally ready to discuss management of their speech problem.

- What have you been told is the cause of this problem?
- What does the diagnosis mean is going to happen?

Examination of the Speech Mechanism During Nonspeech Activities

Observations of the speech mechanism in the absence of speech can be very informative. In general, it provides information about the size, strength, symmetry, range, tone, steadiness, speed, and accuracy of orofacial movements, particularly of the jaw, face, tongue, and palate. The observations are primarily visual and tactual but also rely on auditory information. The milieu in which the observations are made include (1) at rest, (2) during sustained postures, (3) during movement, and (4) reflexes. Evidence from the examination may help confirm conclusions drawn about speech. Even if not confirmatory of a speech deficit, the observations may nonetheless be salient to neurologic evaluation.

The Face at Rest

At rest, the normal face is grossly symmetric and exhibits normal tone and little spontaneous movement. It is neither droopy nor fixed in a posture associated with strong emotion (e.g., smiling, on the verge of tears).

To observe the face at rest, the patient should be instructed to relax, look forward, let the lips part, and breathe quietly through the mouth. Some people can maintain this relaxed posture more easily with their eyes closed.

The following questions should then be answered:

- Is the face symmetric?
- Are the angles of the mouth symmetric?
- Is asymmetry due to a drooping of the entire face on one side, a droop at the corner of the mouth, or flattening of the nasolabial fold?

Recognize that some asymmetry is the rule rather than the exception; a slight difference in the length and prominence of the nasolabial folds is common. Some asymmetry often can be seen at rest or during voluntary and spontaneous or emotional responses (Figure 3-1).

Additional questions include the following:

- Is the face expressionless, masklike, or unblinking? Is it held in a fixed expression of smiling, astonishment, or perplexity? Does the upper lip appear stiff?
- Are abnormal spontaneous, involuntary movements present? Do the eyes shut tightly and uncontrollably? Is there quick or slow symmetric or asymmetric pursing or retraction of the lips? Are there spontaneous smacking noises of the lips? Can the patient inhibit these movements on request? If so, do they reappear when inhibitory efforts cease?
- Are the lips tremulous or are there tremorlike rhythmic movements of the lips? Are *fascicu-lations* present in the face, especially around the mouth or chin?

The Face During Sustained Postures

Observing the face during sustained postures allows additional observations of symmetry, range of motion, strength and tone, and the ability to maintain a sustained posture.

Useful sustained facial postures include retraction of the lips, rounding or pursing of the lips, puffing the cheeks, and sustained mouth opening. The patient should be asked to sustain each posture after it is demonstrated by the examiner (see Figure 3-1).

The following questions should be answered:

- Are lip retraction, rounding, and puffing symmetric? Is their range of movement normal or restricted? When opening the mouth, is the configuration of the lips symmetric or does one side lag?
- Is the patient able to resist the examiner's attempt to push the upper or lower lip toward the midline when the lips are retracted, or resist the examiner's attempt to spread the lips when they are rounded? Does air escape through the lips when the patient puffs the cheeks or can the seal be broken with less than normal pressure when the examiner pushes in on the cheeks?
- Does *tremulousness* appear or disappear during sustained facial postures? Are additional movements present that distort or alter the ability to maintain the sustained posture?
- Can the patient maintain the posture for several seconds or does he or she stop the effort even when instructed to maintain it?

The Face During Movement

The face should be observed during speech, emotional responses, and volitional nonspeech tasks. During speech and emotional responses, range and symmetry of facial movement and expressiveness should be noted.

There is substantial literature on normal facial asymmetry and its determiners. Evidence suggests that the left side of the face is, on average, more active than the right in the expression of facial emotion, with the implication that the right hemisphere—with its predominant control over innervation of the lower left face—is dominant for emotional facial expression.[2] However, data from neurologically intact people show that asymmetries can be seen in favor of the right or left side of the face and that differences are not necessarily compatible with hypotheses about hemispheric specialization[17,42]; differences in facial morphology,
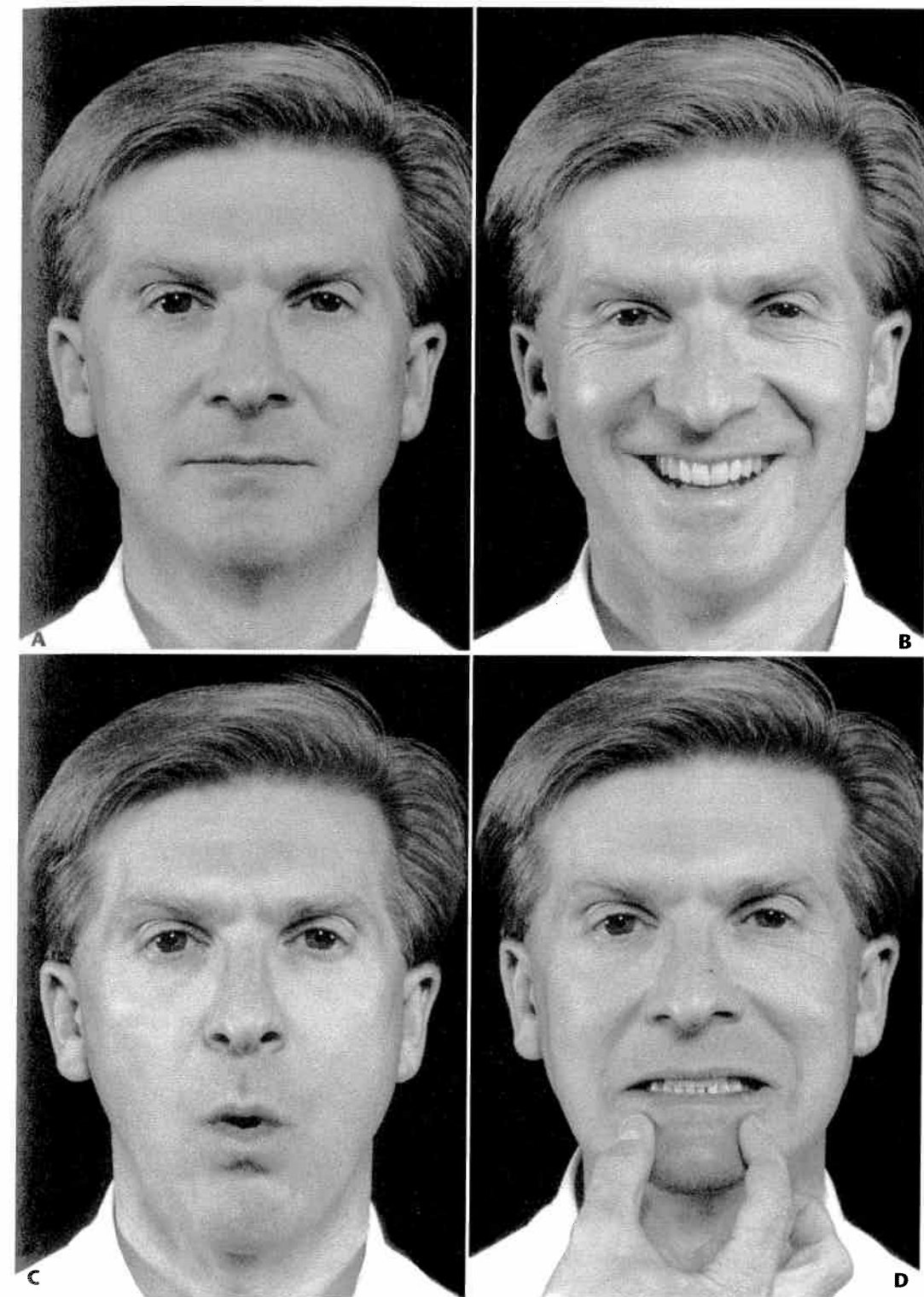

FIGURE 3-1 **A,** The normal face at rest; **B,** during spontaneous smiling; **C,** lip rounding; **D,** lip retraction against pressure.
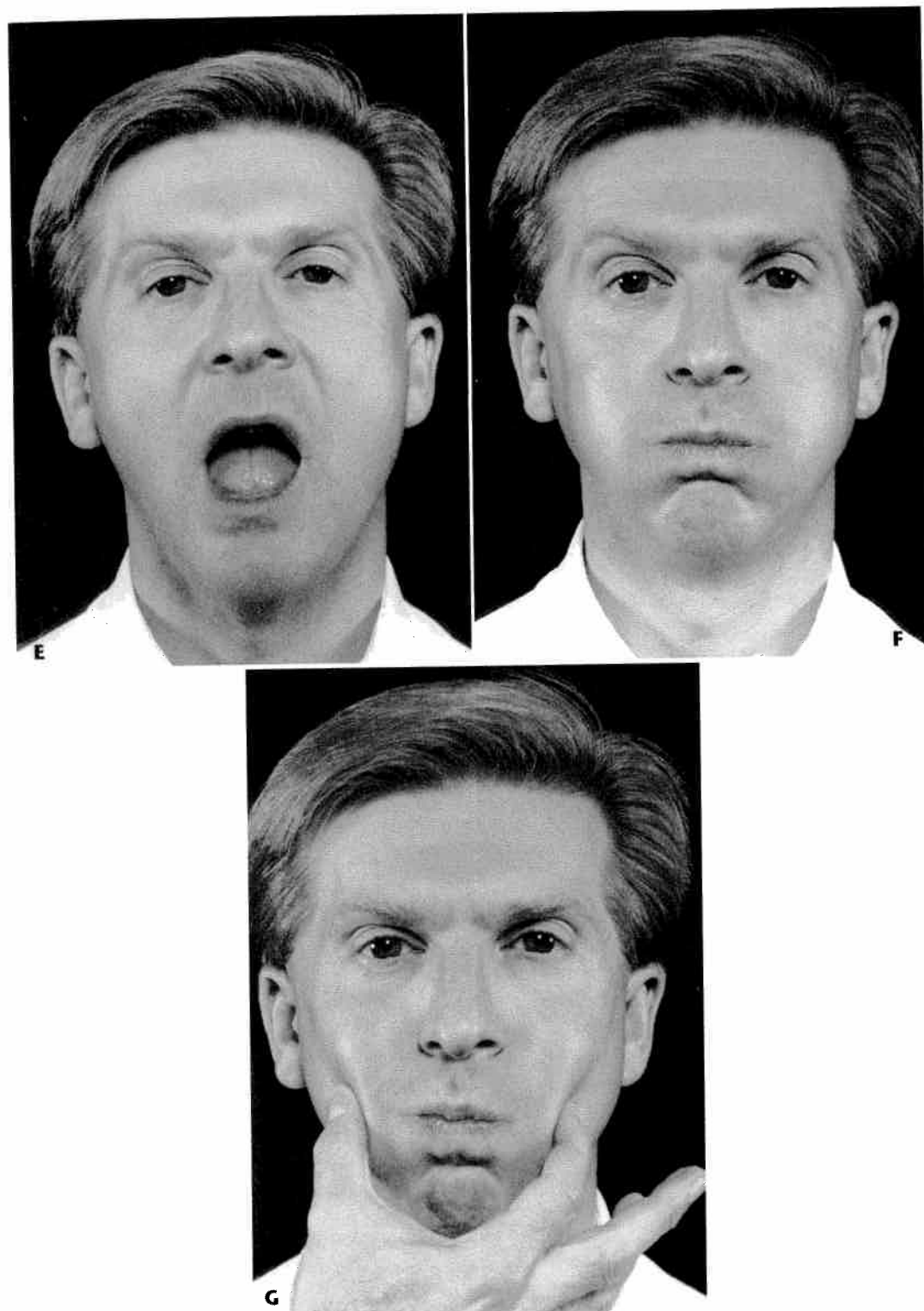
FIGURE 3-1 cont'd. **E,** mouth opening; **F,** cheek puffing; and, **G,** cheek puffing against pressure.

independent of asymmetric neural innervation, may explain some of the differences among people without neurologic disease. Some studies have found differences in facial asymmetry between the sexes and have argued that they are driven by gender-related differences in cognitive processing by the two cerebral hemispheres.[41] Others have concluded that there are no systematic asymmetry patterns, at least during emotional expression, as a function of gender.[3] Finally, a recent study reported that during repetition of single words the right side of the mouth opened to a greater degree in most people during repetition of single words, presumably reflecting left hemisphere dominance for language or speech programming; this was true for both sexes during single word production, but the asymmetries disappeared in women during word series productions.[18]

In light of these very interesting but probably less than reliably predictable clinical differences, what seems important for basic clinical examination is to remember that *mild facial asymmetries—at rest and during speech and nonspeech emotional expression—are not uncommon, but the direction of the asymmetry is not highly predictable.*

It is also important to remember that *the motor control of voluntary facial movement differs from the control of spontaneous expression.* For example, patients with lower facial paresis resulting from CNS lesions sometimes smile symmetrically in response to a joke, but asymmetry can then be evident when they smile voluntarily; the opposite pattern can be seen in some patients with parkinsonism.[35] Thus it is of value to elicit a spontaneous emotional smile and to compare the extent of facial movement during it to that of a voluntary smile or lip retraction.

Nonspeech tasks can include rapid repetitions of lip pursing, lip retraction, and cheek puffing. The patient should be instructed to repeat the movements as rapidly and steadily as possible. Observations of rate, range, and regularity of movement should be made. Observations of symmetry and the occurrence of regular or irregular involuntary movements should be made during speech and emotional responses.

The patient's emotional responses should be observed. The congenial clinician can usually elicit a spontaneous smile from the patient. When this does not happen naturally, asking "If I told you a joke, would you smile?" while smiling at the patient often is sufficient to trigger a smile. The symmetry of smiling and the degree to which the angles of the mouth elevate to normal height (again, recognizing that some asymmetry is normal) should be noted. More important, the degree of movement asymmetry relative to that observed during voluntary lip retraction should be observed.

Does the patient have difficulty inhibiting laughter or crying? This loss of inhibition can become apparent at any time during examination, but one of the simplest ways to trigger disinhibition is to ask the patient "Do you have any difficulty controlling laughter or crying?" It should be recognized, however, that it can be difficult to distinguish crying that reflects a pathologic loss of motor control from crying that may occur as a result of the psychologic distress, sorrow, and depression that can be expected in people who are coping with disease.

The Jaw at Rest

The jaw is usually lightly closed or slightly open at rest. This can be observed when the face is at rest. The following questions should be answered:
- Does the jaw hang lower than normal?
- Are there spontaneous, apparently involuntary quick or slow movements of the jaw, such as clenching, opening or pulling to one side, or tremorlike up and down movements? Has the patient learned any postural adjustments or tricks that tend to inhibit sustained involuntary movements (e.g., clenching the jaw, holding a pipe in the mouth, touching a hand to the side of the jaw or neck)?

The Jaw During Sustained Posture (Figure 3-2)

The jaw can be observed during sustained facial posture tasks, especially during mouth opening (see Figure 3-1, *E*). The following questions should be answered:
- Does the jaw deviate to one side when the patient attempts to open it as widely as possible? Is the patient able to open the mouth widely or is excursion limited?
- Can the patient resist the examiner's attempt to open the jaw when told to clench the teeth? Can the jaw be closed against resistance from the examiner (either by holding the midline of the jaw with the hand or by placing a tongue blade on the lower teeth and resisting closure)? Do the masseter and temporalis muscles have normal bulk and bulge when the patient bites down?
- Can the patient resist the examiner's attempt to close the jaw when told to hold it open?

The Jaw During Movement

The jaw should be observed for symmetry of opening and closing and for range of motion during speech and spontaneous movements. The patient should be asked to rapidly open and close the mouth;
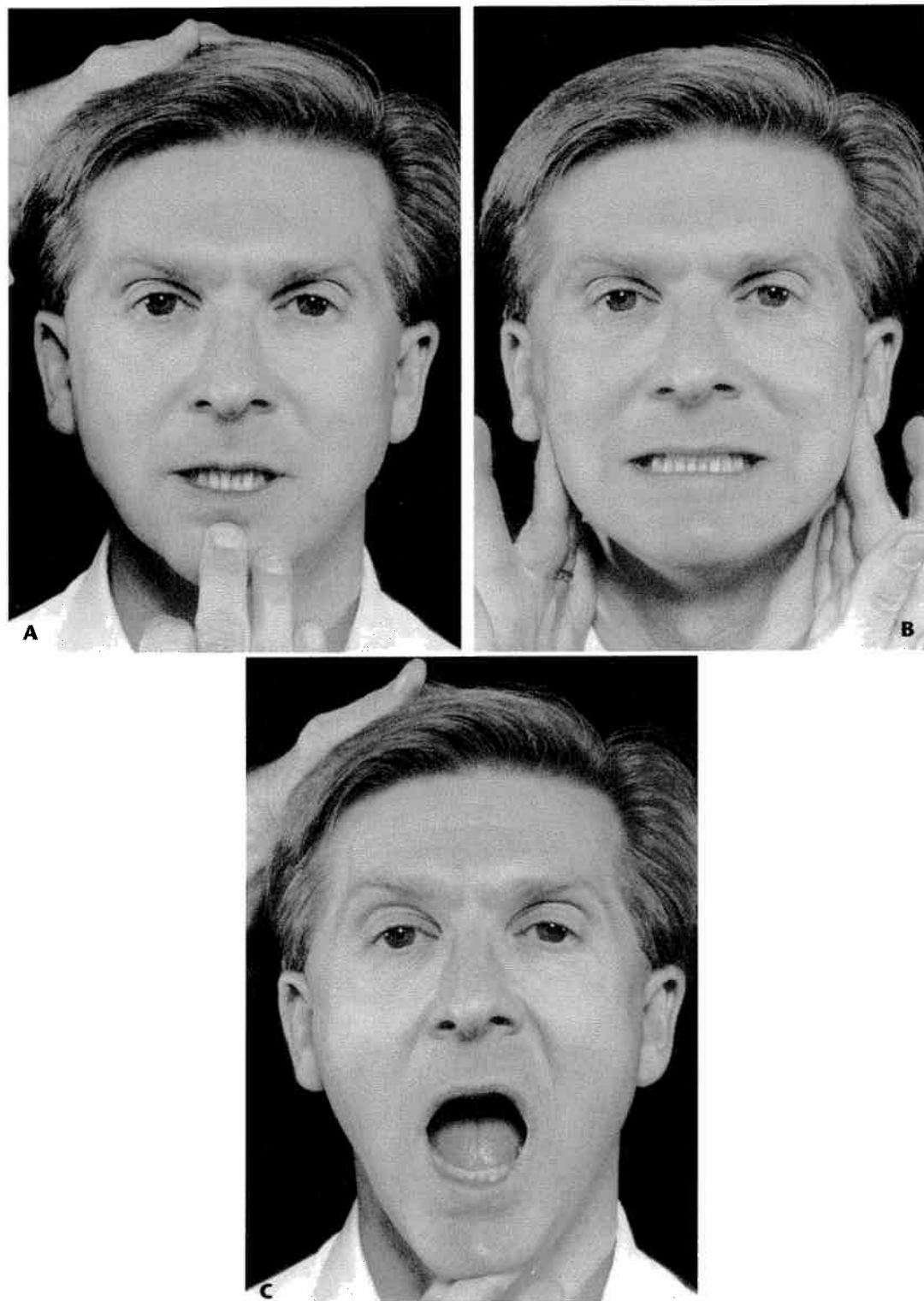
FIGURE 3-2 A, Assessing resistance to jaw opening; **B,** masseter bulk and symmetry during jaw clenching; and, **C,** resistance to jaw closing.

the speed and regularity of movements, as well as involuntary movements that may interrupt the course of jaw alternate motion rates (AMRs), should be noted.

The Tongue at Rest

The tongue should be examined at rest (see Figure 3-1, *E*). The patient should be told to open the mouth, breathe easily, and let the tongue relax on the floor of the mouth. The degree to which the normal tongue lies at rest varies considerably; some low-amplitude spontaneous movement is common. With this in mind, the following questions should be answered:

- Is the tongue full and symmetric? If symmetric, is its size normal? If small, are there symmetric or unilateral grooves or furrowing in the tongue representing atrophy? (Indentations along the tongue's lateral side edges may represent teeth marks and not atrophy.) Are *fasciculations* present (localized twitchlike movements of the tongue)? They are best observed when the tongue is at rest inside the mouth; with the tongue protruded, normal spontaneous movements can be confused with fasciculations.
- Does the tongue remain quiet on the floor of the mouth? Are quick, slow, or sustained movements of large portions of the tongue apparent in the form of protrusion, retraction, lateralization, or writhing?
- Is the tongue (or oral cavity as a whole) excessively wet or dry? Accumulated saliva may reflect excessive secretions or, more likely in people with neurologic disease, failure to adequately clear secretions. *Xerostomia* (dry mouth) can reflect dehydration, inadequate water intake, autoimmune problems, or the effects of various medications or radiation therapy.

The Tongue During Sustained Postures (Figure 3-3)

The patient should be asked to protrude his or her tongue and sustain the posture. Mild deviation toward one side is not unusual, but the direction of
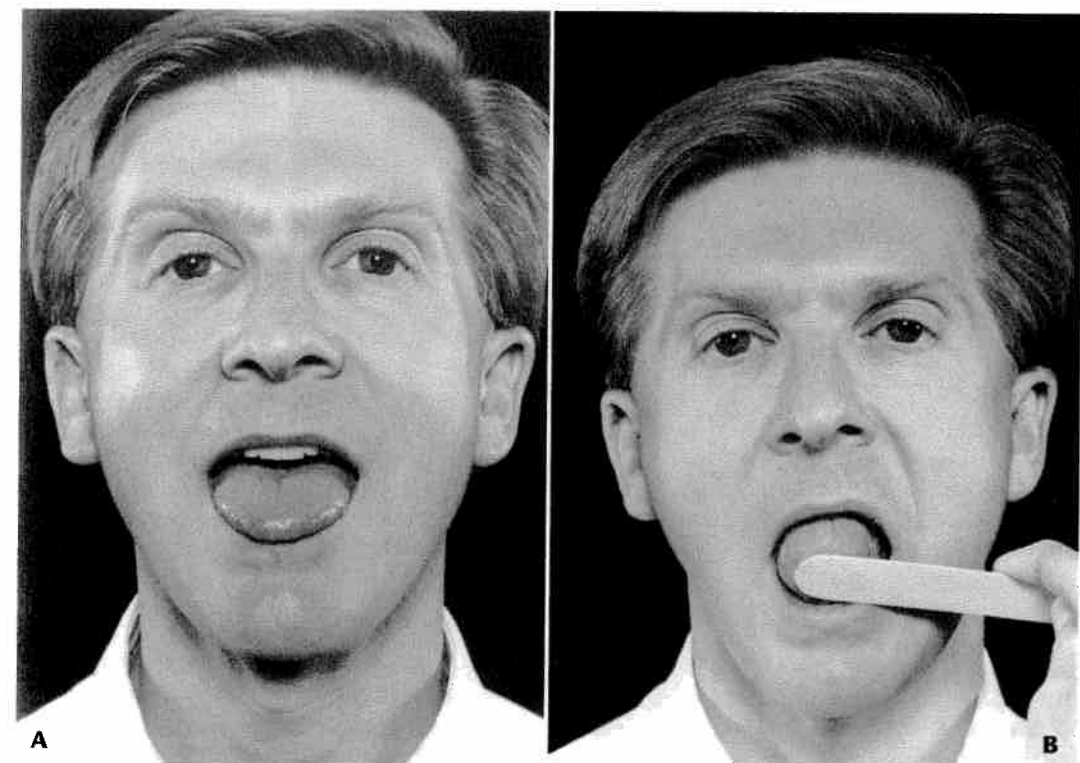

FIGURE 3-3 A, The tongue during protrusion; **B,** resisting pressure to push it inward with a tongue blade.

FIGURE 3-4 A, Position for examining the soft palate and pharynx at rest and during phonation and gagging; and, B, examining for nasal airflow during prolongation of /i/ or production of pressure consonants.
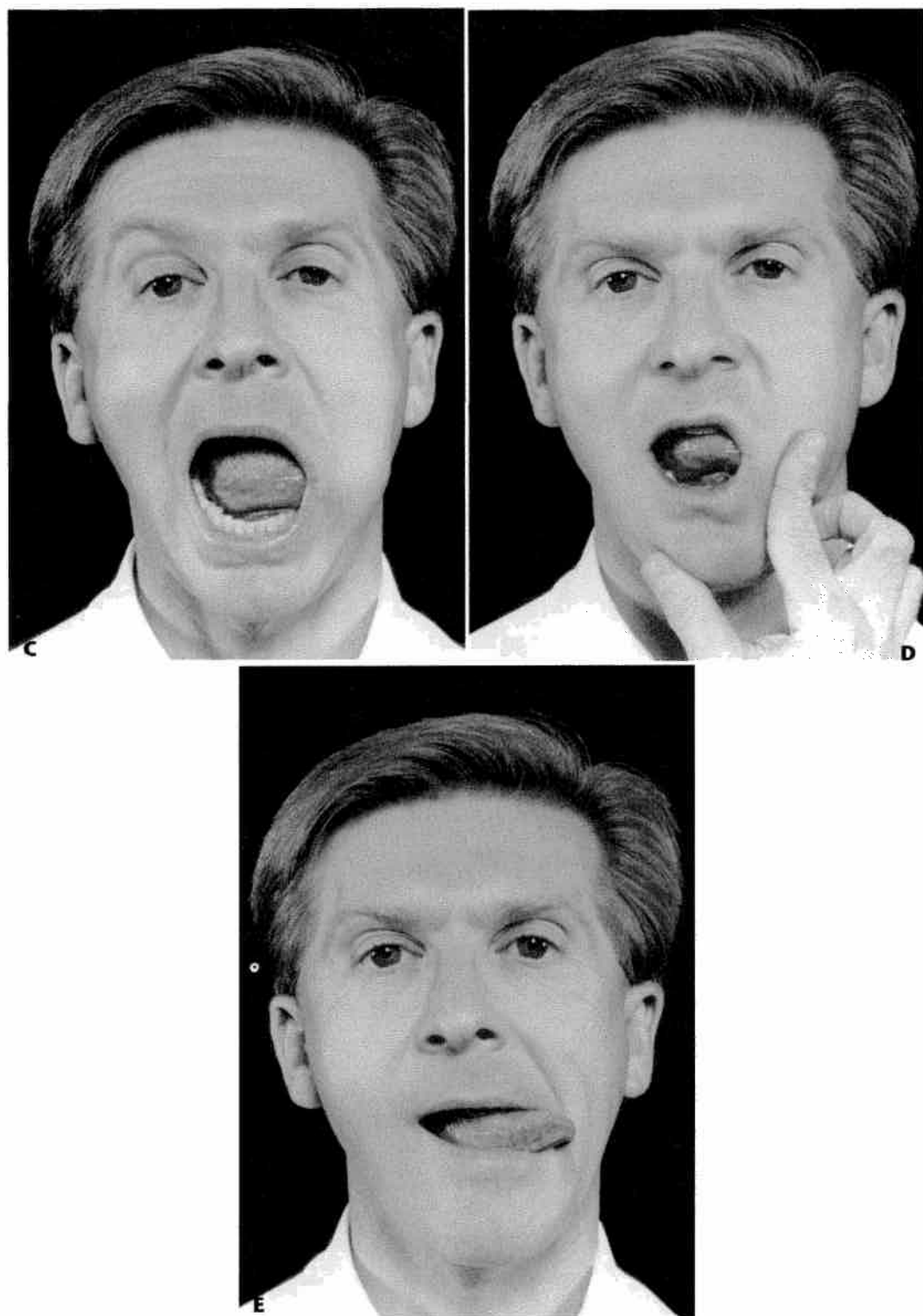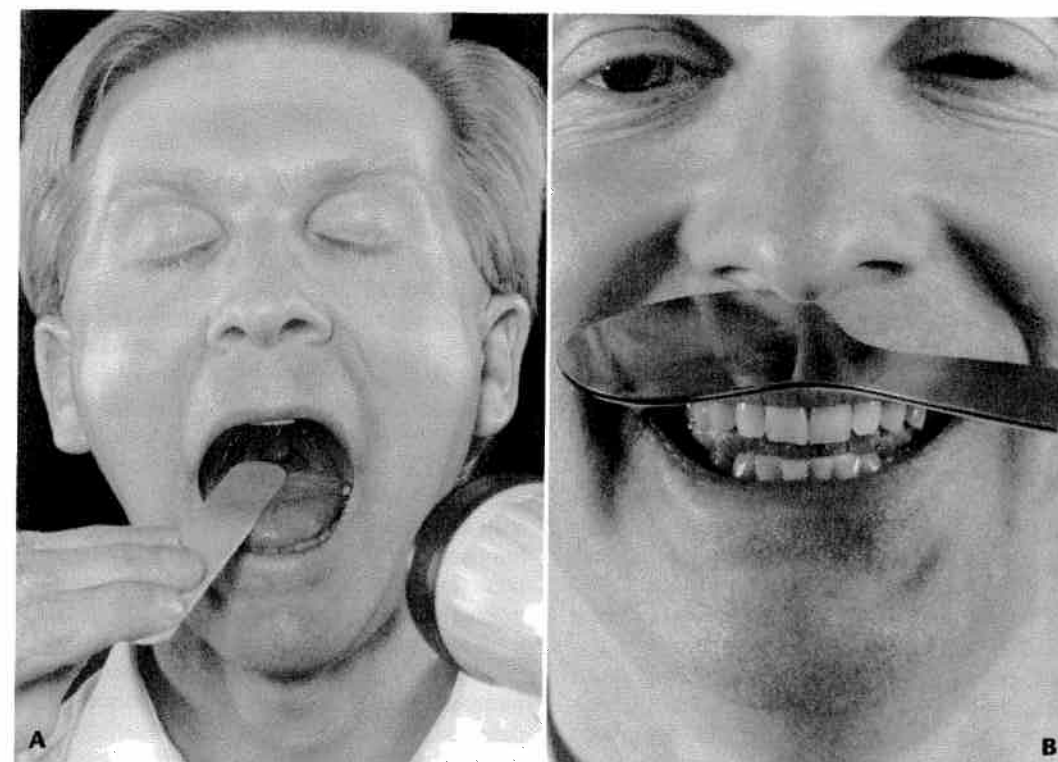
FIGURE 3-3 cont'd. C, lateralizing into the cheek; D, resisting inward pressure when lateralized; and, E, lateralized outside the mouth, as for lateral lingual alternate motion rates.

deviation on repeated trials usually is inconsistent. The meaningfulness of deviation, when subtle, can be determined by having the patient repeat the task several times; consistent deviation to one side may reflect weakness. The following questions should be answered:

- Can the patient protrude the tongue to a normal degree? Does the tongue consistently deviate to one side or the other? Deviation should be judged by the relationship of the tongue to the midline of the chin, especially when unilateral facial weakness is present; an alternative is to hold up the corner of the mouth so that it is roughly symmetric with the unimpaired side, allowing tongue deviation to be judged more validly.
- Can the patient resist the examiner's attempt to push the tongue back into the mouth (a tongue blade placed against the tip of the tongue can be used for this purpose)?

Can the patient push out the cheek on each side with the tongue? If so, can he or she resist pressure from the examiner's finger to push the tongue inward? With the tongue outside the mouth, can the patient resist the examiner's attempt to push the tongue to one side with the tongue blade? Does the

tongue resist pressure at first and then suddenly give way completely?*

The Tongue During Movement

The patient should be asked to move the tongue from side to side as rapidly as possible. Speed, regularity, and range of motion should be noted.

The Velopharynx at Rest

The patient should be asked to open his or her mouth as widely as possible. The tongue should then be depressed gently with a tongue blade (Figure 3-4). The following questions should be answered:

- Does the palate hang low in the mouth? Does it rest on the tongue?

*Lingual strength and fatigue can be assessed in a quantifiable way with an instrument known as the Iowa Oral Performance Instrument (IOPI). The IOPI is an air-filled bulb against which the anterior portion of the tongue is pushed, generating a digital readout or analog signal that indexes pressure. It has been used to identify problems of strength or fatigue in children and adults with different neurologic conditions and types of MSDs.[37]

- Are the palatal arches symmetric or does one side hang lower than another? (Normal palates are often mildly asymmetric, especially after tonsillectomy or palatal surgery.)
- Are there spontaneous rhythmic or arrhythmic beating movements of the palate (i.e., myoclonus)?

The Velopharynx During Movement

The patient should be asked to prolong "ah." Important observations relate to the presence, absence, and symmetry of palatal movement. *Inferences about the adequacy of palatal movement for speech on the basis of simple oral inspection should be avoided.* The following questions should be answered:

- Is palatal movement symmetric? If asymmetric, does the palate elevate more strongly to the side opposite that which hung lower at rest?
- Is there evidence of nasal airflow on a mirror held at the nares during vowel prolongation (see Figure 3-4), prolongation or repetition of pressure sounds (/s/, /p/), or words or phrases with nonnasal consonants? Does resonance change during vowel prolongation with the nares occluded versus unoccluded?

The integrity of velopharyngeal closure also can be addressed indirectly by having the patient puff the cheeks and protrude the tongue simultaneously, a procedure known as the *modified tongue-anchor test*.[8,15] The test derives from observations that patients with palatal weakness sometimes impound intraoral pressure by assisting velopharyngeal closure with the back of the tongue. Tongue protrusion during cheek puffing prevents this valving, so the cheeks cannot be puffed, and air will escape nasally if the palate is significantly weak. It sometimes helps if the examiner occludes the nares while the patient puffs and protrudes the tongue, and then releases the nares, observing whether or not air is then emitted nasally. It is important to demonstrate this task to the patient, because some normal individuals have difficulty understanding or coordinating the movements for it. Only the inability to puff the cheeks because of nasal air escape when the tongue is actually protruded is meaningful to the assessment of velopharyngeal weakness. This test may not be valid if there is significant tongue or facial weakness.

To validly observe velopharyngeal activity during speech, videofluoroscopy or nasoendoscopy is necessary. Lateral, frontal, and basal view videofluoroscopy provide good information about palatal, lateral pharyngeal wall, and sphincteric activity of the velopharyngeal[9] mechanism during speech, as does nasoendoscopy. Lateral view videofluoroscopy

may be sufficient if documentation of palatal weakness is of primary concern.

The Larynx

The gross integrity of vocal fold adduction can be inferred from two tasks. First, the patient should be asked to cough; the important observation is the *sharpness of the cough*, not its loudness. A weak, "mushy," or breathy cough may reflect vocal fold adductor weakness, poor respiratory support, or both. Second, the patient should be asked to produce a *"coup de glotte" (glottal coup)*, which is a sharp glottal stop or grunting sound; this maneuver requires minimal respiratory force and sustained airflow. Again, the *sharpness of the coup* is the important observation. A weak cough but sharp glottal coup may implicate respiratory pathology. A weak coup but normal cough or equally weak cough and coup tends to be associated with laryngeal weakness or combined laryngeal and respiratory weakness.

Weakness of vocal fold abduction can be inferred from the presence of *inhalatory stridor* (noisy or phonated inhalation). This sometimes can be detected during quiet breathing but is more readily detected during rapid inhalation for speech or when the patient takes a deep breath.

Direct visual examination should be pursued whenever structural lesions (e.g., neoplasms, nodules, polyps, inflammation) or LMN lesions of the laryngeal branches of the vagus nerve are a possibility. With regard to CNS lesions, sometimes laryngeal examination identifies vocal fold paresis following UMN stroke[43]; it can also be useful in documenting involuntary laryngeal movements in certain CNS movement disorders. Sophisticated visualization of the larynx can be achieved with an optically precise *rigid oral laryngoscope*, and laryngeal activity during connected speech can be observed with a *flexible fiberoptic laryngoscope*. *Videostroboscopy* with a rigid or flexible scope provides a simulated slow-motion view of the vocal fold mucosal wave during phonatory vibratory cycles and thus visualization of much more subtle abnormalities of vocal fold function. *Electroglottography* and *acoustic analyses* permit the quantification and analysis of various correlates of vocal fold activity during phonation, but they are rarely necessary to basic clinical diagnosis of MSDs.

Respiration

Hixon and Hoit[20-22] have provided comprehensive, noninstrumental protocols for the clinical examination of the diaphragm, abdominal wall, and rib cage wall in people with known or suspected speech breathing difficulty. They describe observations

associated with several tasks that are consistent with normal breathing or with neurologic abnormalities such as weakness, incoordination, and hyperkinesias. They are particularly valuable guides to understanding respiratory movement dynamics and the examination of dysarthric people with prominent or predominant respiratory difficulties. Following is a summary of some useful observations that can be made in the context of a broad-based motor speech examination.

Information about respiratory adequacy for speech can be derived from observations of quiet breathing and a few nonspeech activities. During quiet breathing the following questions should be answered:

- Is posture normal? If not, is the patient slouched in the chair or bent forward or to the side? Does he or she tend to gravitate over time toward abnormal posture, and does it require effort or assistance to resume a more normal posture? Is the head drooped forward? Does it rest on the chest? Is the patient braced in a chair in order to maintain normal posture? Abnormal posture may restrict diaphragm or abdominal or chest wall movements and reduce respiratory support for speech.
- Does the patient complain of shortness of breath at rest, during physical exertion, or during speech? Is breathing rapid, shallow, or labored? (Rate of quiet breathing during wakefulness is about 16 to 18 cycles per minute with each inspiratory and exhalatory cycle taking 2 to 3 seconds.) Are abdominal or chest wall movements asymmetric or limited in range during rest breathing, speech, or maximum inspiration? Is breathing accompanied by shoulder movement, neck extension, retraction of the neck just above the upper sternum on inhalation, or flaring of the nares on inhalation? Rapid, shallow breathing and excessive assistive shoulder or neck movement during breathing may reflect respiratory weakness and predict reduced loudness or phrase length.
- Is breathing rate irregular? Are there any abrupt or slow abdominal or chest wall movements that alter or interrupt normal cyclical breathing during rest breathing, speech, or maximum inspiration? Such irregularities may reflect a movement disorder and predict abnormalities in loudness, prosody, or phrasing.
- Does the patient have *hiccups (singultus)?* Persistent hiccups can be caused by lesions in the medulla and may be an initial manifestation of medullary stroke.[34] They can obviously interfere with respiratory control during speech.
- Sophisticated pulmonary function tests can quantify and often explain sources of abnormal
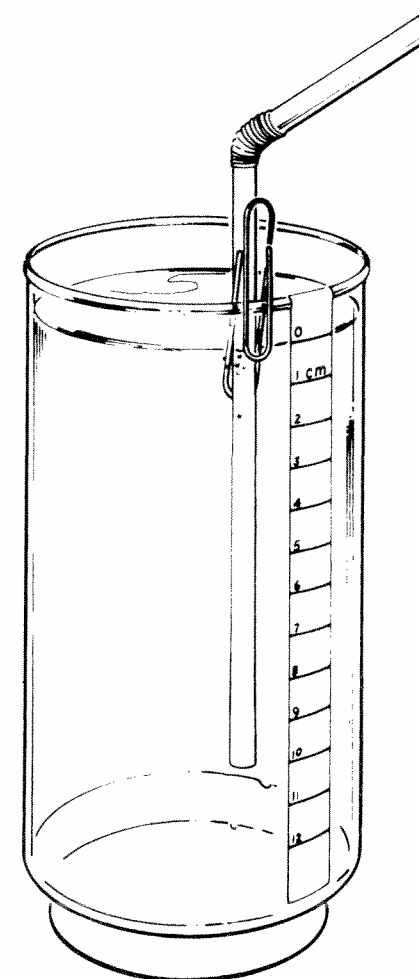
FIGURE 3-5 Water glass manometer for determining ability to generate and sustain respiratory driving pressure sufficient for speech. (From Hixon TJ, Hawley JL, Wilson KJ: An around-the-house device for the clinical determination of respiratory driving pressure: a note on making the simple even simpler, *J Speech Hear Disord* 47:413, 1982, used with permission).

respiratory function. However, in most situations in which respiratory weakness may be present, a few simple tasks can help determine if respiratory support is sufficient for speech.

- As already noted, when weakness is suspected, contrasting the sharpness of the cough versus glottal coup may help separate respiratory from laryngeal contributions to reduced loudness or short phrases. A weak cough with limited abdominal and chest wall excursion may reflect respiratory weakness.
- A simple water glass manometer can be used to estimate the ability to generate respiratory driving pressure sufficient for speech[19] (Figure 3-5). It requires a drinking glass (12 cm or

more in depth) filled with water and calibrated in centimeters and a drinking straw that is affixed by a paper clip to the glass at a given depth. To maintain a stream of bubbles through the straw, a person must sustain breath pressure equal to the depth of the straw in the water. The ability to maintain a stream of bubbles for 5 seconds with the straw at a depth of 5 cm suggests that breath support is sufficient for most speech purposes. For this test to be valid as a measure of respiratory support, the patient must be able to maintain velopharyngeal closure (or have the nares occluded) and a tight lip seal around the straw.

Reflexes

Reflexes can provide confirmatory clues about the gross localization of disease in the CNS or PNS. Those that can be tested in the context of the speech mechanism examination include normal reflexes and primitive or pathologic reflexes. *Normal reflexes are those that reflect normal nervous system function.* Their absence can reflect PNS pathology. *Primitive (or pathologic) reflexes are present during infancy but tend to disappear during maturation;* they may then reappear in the presence of CNS disease, most often in frontal lobe cortical and subcortical regions. Pathologic reflexes represent a *release phenomena,* or reduction of cortical inhibitory influence on lower centers of the brain.

Normal reflexes vary greatly among individuals in the ease with which they are elicited and in the amplitude of the response. Primitive reflexes are present in a certain percentage of normal adults, a percentage that generally increases with age.[23] Therefore the results of oromotor reflex testing can be ambiguous. Cautious interpretation of reflexes as pathologic is required, and not much should be made of them when they are minimally or equivocally present.

1. *Gag reflex*—The gag or pharyngeal reflex is a normal reflex elicited by stroking the back of the tongue, posterior pharyngeal wall, or faucial pillars on both sides with a tongue blade. The afferent pathway for the stimulus is through the glossopharyngeal nerve; the motor response is through the glossopharyngeal and vagus nerves. Elevation of the palate, retraction of the tongue, and sphincteric contraction of the pharyngeal walls characterize the reflex. Normal responses vary greatly, ranging from no response to a vigorous gag elicited merely by touching the tongue.

FIGURE 3-6 Position for eliciting the jaw jerk reflex (procedure and response described in text).

In general, the gag reflex is clinically significant only if it is asymmetrically elicited. If absent on one side but not the other, it is probably abnormal on the unresponsive side. When asymmetric it is useful to ask the patient if the stimulus feels different between the two sides; if so, reduced sensation may be responsible for the decreased reflex response. If reported sensation is not different, the motor component of the reflex may be deficient.

2. *Jaw jerk*—The jaw jerk (or maxillary reflex) is a deep muscle stretch reflex that may be pathologic when exaggerated or easily elicited in adults. To test for it, the patient should be relaxed, with the lips parted and the jaw about halfway open. A tongue blade (or fingertip) is placed on the patient's chin, and the blade is then tapped with a reflex hammer or a finger of the other hand (Figure 3-6). The mandibular branch of the trigeminal nerve mediates the afferent and efferent components of the reflex. The reflex is characterized by contraction of the masseter and temporalis muscles, leading to a quick jerk of the jaw toward closing.[4]

FIGURE 3-7 Position for eliciting the sucking reflex (procedure and response described in text).

FIGURE 3-8 Position for eliciting the snout reflex (procedure and response described in text).

The jaw jerk is present in about 10% of normal adults.[44] When exaggerated, however, its presence may be confirmatory of bilateral UMN disease above the level of the trigeminal nerve nuclei in the mid pons.

3. *Sucking reflex*—The sucking reflex is a primitive reflex. It is tested by stroking the upper lip with a tongue blade, beginning at the lateral aspect of the upper lip and moving medially toward the philtrum (Figure 3-7). This should be done on both sides. There usually is no response to the stimulus in adults. The positive or pathologic response is a pursing or pouting of the lips. When present, it can be confirmatory of UMN disease above the level of facial nerve nuclei in the pons. It tends to correlate with diffuse involvement of premotor areas of the frontal lobes and is frequently elicited in patients with dementia.[4,44]

When the sucking reflex is very exaggerated, the patient may purse the lips as an object approaches the mouth or may turn the mouth toward a tactile stimulus to the corner of the mouth or cheek. When this occurs, it is called a *rooting reflex.*

4. *Snout reflex*—The primitive snout reflex is similar to the sucking reflex. It can be elicited by a light tap of the finger on the philtrum or tip of the nose[16] (Figure 3-8) or by backward pressure of the examiner's index finger on the midline of the patient's upper lip and philtrum.[23] The reflex is a puckering or protrusion and elevation of the lower lip and depression of the lateral angles of the mouth. Its presence must be interpreted cautiously, because it is present in 17% of normal adults from the third to ninth decades of life, with about double that incidence in people older than age 60.[23]

5. *Palmomental reflex*—The palmomental reflex is a primitive reflex that is elicited by vigorously stroking a blunt object (e.g., a tongue blade) across the palm of the hand. The reflex response is a brief contraction of the mentalis muscle, seen as a slight elevation of muscles in the ipsilateral chin. When pronounced, it may indicate damage to the contralateral paracentral cortex or its projection fibers.[4] Again,

however, about 37% of normal adults from the third to ninth decades have the reflex, with incidence increasing to 60% in the ninth decade.[23] Thus its frequent presence in adults without neurologic disease suggests that it should be interpreted as possibly meaningful only when it is present unilaterally.

Volitional versus "Automatic" Nonspeech Movements of Speech Muscles

Differences can exist between nonspeech volitional movements of speech muscles and movements during relatively automatic or overlearned responses. Differences between movements of the face during emotional responding and voluntary performance have already been discussed.

Just as speech programming ability can be stressed or facilitated, so too can nonspeech programming ability. Whenever supratentorial lesions (particularly dominant hemisphere lesions) or apraxia of speech or aphasia are suspected, the ability to imitate or follow commands for nonspeech movements of the speech muscles should be examined. The goal is to test for *nonverbal oral apraxia*.

The tasks are simple, and several of them are identical to those used in routine oral mechanism examination. They are best elicited by verbal command, but if verbal comprehension is impaired (often the case when aphasia is present), or if the patient comprehends but has difficulty performing a task, imitation should also be used.

The observations are different than those during routine oral mechanism examination. They focus on the ability to perform without off-target approximations, frank errors, or a frustrating awareness that performance is incorrect with accompanying attempts at self-corrections. For example, asked to cough, patients with nonverbal oral apraxia sometimes say "cough, cough" or "huh, huh," then recognize the response's inadequacy and attempt to self-correct. They often improve on imitation but may be inaccurate if tested again a few moments later. Such patients often reflexively perform the acts they cannot do when requested (e.g., unable to cough on command, they may later cough reflexively). These discrepancies reflect a nonverbal oral apraxia and dominant hemisphere pathology. They are frequently but not invariably associated with apraxia of speech and aphasia. Some tasks that are useful for eliciting nonverbal oral apraxia are provided in Box 3-1.[9]

Assessment of Perceptual Speech Characteristics

MSDs can be assessed in many ways. What is important is that the examination elicit behaviors that are

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box 3-1 Tasks for assessing nonverbal oral movement control and sequencing

Instructions: Ask the patient to perform the following tasks. If he or she fails to respond to a command, use imitation. The following code can be used to score responses:

4. Accurate, immediate, effortless
3. Accurate but awkwardly or slowly produced
2. Accurate after trial and error searching movements
1. Inaccurate or only partially accurate; important component missing or off target

NR = No response

V = Accompanying or substituted **v**ocalization or **ver**balization (e.g., patient says "cough" instead of coughing)

P = **P**erseverative response

Item	Command	Imitation
1. Cough	___	___
2. Click your tongue	___	___
3. Blow	___	___
4. Bite your lower lip	___	___
5. Puff out your cheeks	___	___
6. Smack your lips	___	___
7. Stick out your tongue	___	___
8. Lick your lips	___	___
9. Bite your lower lip and then click your tongue	___	___
10. Smack your lips and then cough	___	___

Modified from Darley FL: Differential diagnosis of acquired motor speech disorders. In Darley F, Spriestersbach D, editors: *Diagnostic methods in speech pathology,* ed 2, New York, 1978, Harper & Row.

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critical to diagnosis and management. It is also important to recognize that *what must be done for diagnostic purposes may not be identical to what is done to establish recommendations for management.* The focus at this point is on methods for identifying the perceptually salient deviant dimensions of speech that lead to diagnosis.

The most useful method for establishing deviant perceptual characteristics of speech derives from the work of DAB. Because their work has been so influential to the understanding of the dysarthrias, and because it remains so clinically relevant, a brief summary of the foundation on which the clinical differential diagnosis of the dysarthrias is based is appropriate.*

*See Duffy and Kent[11] for a summary of DAB's contributions to the understanding and scientific study of the dysarthrias, as well as some thoughts about gaps in knowledge and directions for future research.

The Mayo Clinic Dysarthria Studies

The classic text *Motor Speech Disorders*[10] was the outgrowth of extensive clinical research and two important articles that summarized those research efforts.[11,12]

DAB[11,12] analyzed speech samples from 212 patients. A minimum of 30 patients fell into seven groups: (1) bulbar palsy, (2) pseudobulbar palsy, (3) cerebellar lesions, (4) parkinsonism, (5) dystonia, (6) choreoathetosis, and (7) amyotrophic lateral sclerosis (ALS). These groups are equivalent to the categories of flaccid, spastic, ataxic, hypokinetic, hyperkinetic (dystonia and choreoathetosis), and mixed dysarthria, respectively, discussed by DAB in their 1975 book and by many subsequent clinicians and investigators. Each patient had unequivocal neurologic signs and symptoms that placed them into one and only one of the seven groups. Speech was abnormal in all cases. Speech characteristics had not been used to establish neurologic diagnoses.

Audio-recorded samples of reading and, in some cases, conversation and sentence imitation, were reviewed. A list of 38 speech and voice dimensions that seemed pertinent to the range of speech disorders was compiled. The dimensions were related to pitch, loudness, voice and resonance, respiration, prosody, and articulation. Two overall dimensions, intelligibility and bizarreness, were also included.

The authors listened up to 38 times to each sample within each neurologic diagnostic category, each time rating one of the 38 dimensions (certain economies were adopted so that 38 repetitions were not always necessary) on a 7-point, equal-appearing interval scale. Acceptable temporal and interjudge reliability were obtained.

The deviant speech characteristics for each of the seven groups were analyzed in a manner that allowed comparisons among groups and identification of the most distinctive features within each group. "Clusters" of deviant speech characteristics were also identified. *Clusters represented the tendency for certain deviant speech dimensions to coappear in certain groups of patients.* Each group had a unique pattern of clusters that were logically related to the presumed neuromuscular substrate of the particular neurologic disorder. The analysis also permitted certain inferences about the neuromuscular bases for individual deviant speech characteristics.

DAB expressed hope that their conclusions would serve as hypotheses for "more accurate physiologic and neurophysiologic measurements to further delineate the problems of dysarthria."[12] This was certainly the case, and many subsequent acoustic and physiologic studies have related their findings to the hypotheses of DAB. In addition, numerous subsequent perceptual studies of dysarthria associated with specific neurologic diseases have relied on DAB's methods or the deviant dimensions identified by them. Finally, many clinicians who must differentiate among the dysarthrias rely on their ability to recognize the deviant characteristics and clusters of deviant speech characteristics identified in the work of DAB and subsequent investigators.

Distinctive Speech Characteristics

The distinctive speech characteristics encountered in each of the dysarthrias are addressed in chapters dealing with each dysarthria type. Appendix A lists the 38 dimensions and their definitions, plus several additional characteristics that are relevant to the description of dysarthric speech. The reader should become familiar with all of these terms, because they form the foundation for all subsequent discussion of the dysarthrias.

Box 3-2 is a rating form that may be useful for identifying and rating deviant speech dimensions. It contains all of the characteristics listed in Appendix A. Several features added to the 38 characteristics of DAB are task specific (e.g., AMRs, vowel prolongation).

In our clinic, we rate speech dimensions on a 0 to 4 scale of abnormality (0 = normal, 1 = mild, 2 = moderate, 3 = marked, 4 = severe). This departure from the 7-point scale used by DAB is unimportant, because *the presence of a deviant speech characteristic is generally more important to differential diagnosis than its severity.* The reason for the 0 to 4 scale is its correspondence to commonly used terms for severity (normal, mild, moderate, marked, severe) and its correspondence to the 0 to 4 scale used by many neurologists to rate motor and sensory examination results. It should be noted that the scale can be expanded by 4 points using ratings between categories if necessary (e.g., 0,1 = equivocally present, 2,3 = moderate-marked impairment). Certain dimensions can also be rated plus or minus. For example, rating of reduced loudness can be modified by a minus, increased loudness modified by a plus; when pitch is high it is rated plus, when low minus; when rate is slow it is rated minus, when fast plus. With training and experience, clinicians achieve acceptable reliability when making severity ratings with this scale. The most important challenge to the clinician's ear for diagnostic purposes is learning to detect the presence of deviant dimensions. This is met by experience and the opportunity to check reliability with an experienced clinician.*

*A major assumption about the perceptual evaluation of MSDs is that it can be accomplished reliably. Yet such reliability cannot be assumed because perceptual judgments about any behavior can be unreliable. In fact, there are data that document unreliability

| box 3-2 | Form for rating deviant speech characteristics associated with dysarthria |

Name: _____ Speech diagnosis: _____
Neurologic diagnosis: _____
Age: _____ Date of examination: _____

Dysarthria Rating Scale

Rate speech by assigning a value of 0-4 to each of the dimensions listed below (0 = normal; 1 = mild; 2 = moderate; 3 = marked; 4 = severely deviant). When appropriate, use + to indicate excessive or high and – to indicate reduced or low.

Pitch	Pitch level (+/–) _____ Pitch breaks _____ Monopitch _____ Voice tremor _____ Myoclonus _____ Diplophonia _____	Respiration	Forced inspiration- expiration _____ Audible inspiration _____ Inhalatory stridor _____ Grunt at end of expiration _____
Loudness	Monoloudness _____ Excess loudness variation _____ Loudness decay _____ Alternating loudness _____ Overall loudness (+/–) _____	Prosody	Rate _____ Short phrases _____ Increased rate in segments _____ Increased rate overall _____ Reduced stress _____ Variable rate _____ Prolonged intervals _____ Inappropriate silences _____ Short rushes of speech _____ Excess & equal stress _____
Voice quality	Harsh voice _____ Hoarse (wet) _____ Breathy voice (continuous) _____ Breathy voice (transient) _____ Strained-strangled voice _____ Voice stoppages _____ Flutter _____	Articulation	Imprecise consonants _____ Prolonged phonemes _____ Repeated phonemes _____ Irregular articulatory breakdowns _____ Distorted vowels _____
Resonance (& intraoral pressure)	Hypernasality _____ Hyponasality _____ Nasal emission _____ Weak pressure Consonants _____	Other	Slow AMRs _____ Fast AMRs _____ Irregular AMRs _____ Simple vocal tics _____ Palilalia _____ Coprolalia _____

Modified from dimensions used in Mayo Clinic dysarthria studies,[11,12] plus additional features that may help characterize dysarthria. *AMRs*, Alternating motion rates.

among clinicians and students making perceptual judgments about MSDs.[24,39,40,51,52] However, Kent et al.[29] note that methods used to study reliability probably have not reflected the procedures typically used in clinical practice, and that "the entire examination in either neurology or speech-language pathology may have a robustness that transcends the limitations of individual components of the examination." Duffy and Kent,[13] while stressing the importance of reliability to perceptual descriptions and the diagnosis of dysarthrias, also observed that "it is equally important that studies of reliability, and efforts to train reliability, use methods that represent, approximate, or at least recognize the clinical processes and strategies for arriving at diagnostic conclusions that are used by expert clinicians. If this is ignored, there is a risk that the DAB classification system will be indicted for poor reliability on the basis of evidence derived from studies that have used invalid methods to examine the issue."

Once the ratings have been compiled, they can be used to describe the patient's speech. Experienced clinicians reading an accurate description of deviant speech characteristics often can recognize the important clusters and arrive at an accurate diagnosis without hearing the speech sample. This is not advisable for clinical practice, but it does demonstrate the usefulness of describing speech in this manner.

"Styles" Used for Perceptual Analysis

A symphony can be parsed and its complex underpinnings understood through a careful analysis of its notes, cadence, instruments, and the interactions and temporal relationships among them. Its theme, moods, and message, on the other hand, are best appreciated simply by "taking in" its performance, associating its emotional message with past experience, and appreciating its unique character.

Distinguishing among the dysarthrias can be approached in similar ways. Less experienced clinicians often must be analytic in their approach to diagnosis because they do not yet have an internalized perceptual representation of the dysarthrias for reference. As a result, they carefully identify and list speech characteristics and then match them against the characteristics associated with various dysarthria types. This process is valuable because it trains the ears to recognize salient speech features, and because it is essential to documenting the presence and severity of deviant speech features. What can be missed by this analytic process, however, is the message conveyed by the constant but temporally varying interactions among all of the individual's normal and abnormal speech characteristics. This appreciation of gestalt cannot be obtained by a checklist approach alone.

Experienced clinicians often arrive at a diagnosis by synthesis or complex pattern recognition. They may recognize the speech pattern as a familiar tune, the category of tune represented by a specific dysarthria type. When this occurs, the purpose of listing deviant speech characteristics is to document their presence and severity and summarize some of the reasons for the diagnosis. The risk of this synthesizing approach is that unique and important characteristics may be missed or dismissed, with resultant misdiagnosis. The "taking in" of the pattern of speech, however, can be the most sensitive, reliable, and efficient route to diagnosis.

Tasks for Speech Assessment

A small number of well-selected speech tasks can elicit most of the information necessary for a description and interpretation of abnormal speech. The most important tools for analyzing this information are the ears and eyes of the clinician and an audio or audio-video recorder for repeated analyses when necessary.

The following tasks are designed to isolate as well as possible the respiratory-phonatory, the velopharyngeal, and the articulatory systems for independent assessment and then observe them working together. Because the various tasks differ in their sensitivity to various disorders,[26] their combined use helps ensure detection of deficits that are important to distinguishing among different MSDs.

1. *Vowel prolongation*—Phonation cannot be assessed independent of respiratory function, and disorders at one level can affect function at the other. Fortunately, voice and speech are relatively resistant to respiratory disturbance.

As a result, most neurologic voice abnormalities implicate the laryngeal mechanism rather than the respiratory system.

The simplest task for isolating the respiratory-phonatory system for speech is vowel prolongation. The patient should be instructed to *"take a deep breath and say 'ah' for as long and as steadily as you can, until you run out of air."* This should be followed by a few-second example by the clinician. It is best not to specify pitch or loudness level, because most patients will automatically respond at their habitual pitch and loudness level. If the pitch or loudness produced is noticeably different from conversational levels, the patient should be reinstructed to repeat the task more naturally. It may be necessary to instruct the patient to be higher or lower in pitch, or quieter or louder, and it is often necessary to ask the patient to persist in duration.

The dimensions to be attended to are those categorized under pitch, loudness, and voice quality in Box 3-2. Monopitch and monoloudness should not be rated, because they represent the goal during vowel prolongation. The maximum duration of the vowel should be noted. Maximum vowel duration varies widely among normal speakers; in general, in the absence of other evidence of respiratory or laryngeal abnormality, durations that exceed 8 or 9 seconds can be considered within the normal range for most people (see Table 3-2 for a summary of expected

| table 3-2 | Maximum phonation duration in seconds for the vowel /a/, representing averages across studies of young and elderly (generally older than age 65) male and female adults summarized in Kent, Kent, and Rosenbek's[27] review of maximum performance tests of speech production. Standard deviations are given in parentheses. |

	Median*	Minimum†	Maximum‡
Young males	28.5 (8.4)	22.6 (5.5)	34.6 (11.4)
Young females	22.7 (5.7)	15.2 (4.1)	26.5 (11.3)
Elderly males	13.8 (6.3)	13.0 (5.9)	18.1 (6.6)
Elderly females	14.4 (5.7)	10.0 (5.6)	15.4 (5.8)

*Median value of the means and standard deviations reported across studies.
†Lowest mean and lowest standard deviation reported across studies.
‡Highest mean and highest standard deviation reported across studies.
Note: The median of the minimum values in the ranges reported for young males = 15; for young females = 11.8; for elderly males = 8.5; and for elderly females = 6.5.

vowel duration values). Vowel duration can be used as baseline data against which future comparisons can be made, especially when the examiner is convinced that a maximum effort has been made. Acoustic analysis can be used to quantify a number of parameters of voice during vowel prolongation that may be relevant to the description of a dysarthria. For example, it can help disambiguate perceptual uncertainty about whether a tremor is present and can quantify tremor frequency when it is present; measures of variability of fundamental frequency "may be one of the useful indices of phonatory function in relation to neurologic disorder."[30] Direct visualization of the larynx, including videostroboscopy, can identify movement patterns that can confirm or clarify abnormalities associated with paralysis, weakness, tremor, myoclonus, dystonia, and so on.

The jaw, face, tongue, and neck should be observed during vowel prolongation. Patients may display adventitious movements of those structures during what should be a fixed posture task. Quick or slow adventitious movements could represent an underlying movement disorder.

It is appropriate to identify here a disturbance that can compromise the validity of any task designed to assess physiologic support for speech that requires sustained effort or maximum performance. Some patients with damage to the cerebral hemispheres, particularly the right hemisphere, exhibit *motor impersistence,* an inability to maintain simple voluntary acts, such as keeping the eyes closed. When present, motor impersistence may lead to markedly reduced (e.g., <3 seconds) maximum vowel duration, poorly sustained postures during oral mechanism examination—such as keeping the mouth open or protruding the tongue—or poorly sustained speech AMRs or sequential motion rates (SMRs). Motor impersistence probably reflects impairment of mechanisms that permit sustained attention to maintain motor activity.[33] It is not due to reduced physiologic support for motor activity. When present, its possible influence on examination results must be considered.

2. *Alternating motion rates*—AMRs, or *diadochokinetic rates,* are very useful for determining the speed and regularity of reciprocal movements of the jaw, lips, and anterior and posterior tongue. They also permit assessment of articulatory precision, the adequacy of velopharyngeal closure, and respiratory

and phonatory support for sustaining the task. These latter observations are usually secondary. *The primary value of AMRs is for assessing speed and regularity of rapid, repetitive articulatory movements.*

The patient should be instructed to *"take a breath and repeat 'puh-puh-puh-puh-puh' for as long and steadily as you can."* This should be followed by a 2- to 3-second example by the clinician. Although the task is to perform for as long as possible, a 3- to 5-second sample usually suffices. Patients can be told to stop when the sample is sufficient for clinical judgments.

When repetitions of /pʌ/ are completed, the patient should be asked to repeat the task for /tʌ/ and /kʌ/. AMRs for other consonant-vowel (CV) syllables can be pursued if other places and manners of articulation are of interest.

Inability to sustain speech AMRs for more than a few seconds often reflects inadequacies at the respiratory-phonatory or velopharyngeal levels. When patients adopt a repetitive rhythm or peculiar cadence, or have difficulty producing regular repetitions, they should be reinstructed or even allowed to practice at a slowed rate before being asked to produce maximum rates. Some patients will produce rapid AMRs at the expense of precision; they should be instructed to go as fast as they can without being imprecise.

Speech AMRs for /pʌ/, /tʌ/, and /kʌ/ usually can be produced precisely at maximum rates of five to seven repetitions per second, with repetition of /kʌ/ usually somewhat slower than /pʌ/ or /tʌ/. Approximate expected values for speech AMRs are summarized in Table 3-3. Acoustic analysis software is now available that will quantify rate and regularity of AMRs automatically, but rates can be adequately estimated with a stopwatch. Experienced clinicians can make judgments of speed and regularity without explicitly computing rate and variability, and the same 0 to 4 scale used for rating perceptual speech characteristics of speech can be employed to do so. For example, mildly slowed AMR rate would be rated −1, severely slowed rate (≈ 1/sec) would be rated −4; markedly rapid rate would be rated +3, and so on. Similarly, mildly irregular AMRs would be rated 1, moderately irregular AMRs rated 2, and so on.

Range of motion of the jaw and lips during speech AMRs should be observed, because it is reduced or variable in some dysarthrias.

table 3-3	AMR and SMR performance for normal adults across studies of young and elderly adults summarized in Kent, Kent, and Rosenbek's[27] review of maximum performance tests of speech production. Standard deviations are given in parentheses.

Motion Rate Task	Median*	Minimum†	Maximum‡
/pʌ/	6.3 (0.7)	5.0 (0.4)	7.1 (1.2)
/tʌ/	6.2 (0.8)	4.8 (0.4)	7.1 (1.1)
/kʌ/	5.8 (0.8)	4.4 (0.6)	6.4 (1.1)
/pʌtʌkʌ/	5.0 (0.7)	3.6 (0.3)	7.5 (1.3)

AMR, Alternating motion rate; *SMR,* sequential motion rate.
*Median value of the means and standard deviations reported across studies.
†Lowest mean and lowest standard deviation reported across studies.
‡Highest mean and highest standard deviation reported across studies.
Note: The median of the minimum values in the ranges reported for /pʌ/ = 4.8; for /tʌ/ = 4.4; for /kʌ = 4.4; and for /pʌtʌkʌ/ = 4.3.

The rhythmicity of jaw and lip movements should also be observed, because evidence of incoordination can sometimes be seen. Finally, interruptions or extraneous movements of the jaw, lip, and tongue should be noted (e.g., tongue protrusion, lip retraction or pursing, lip smacking), because they may represent an underlying movement disorder.

Speech AMRs are generally slow or normal in rate in people with MSDs, but rapid or accelerated rate can also be pathologic. Irregular AMRs are encountered in some but not all MSDs. Abnormalities of rate and regularity of AMRs are very useful in the identification of several dysarthria types.

3. *Sequential motion rate*—SMR is a measure of ability to move quickly and in proper sequence from one articulatory position to another. Relative to AMRs, sequencing demands for SMRs are heavy; for this reason, *SMRs are particularly useful when apraxia of speech is suspected.*

The patient should be asked to *"take a breath and repeat 'puh-tuh-kuh' over and over again until I tell you to stop."* This should be followed by a 2- to 3-second example by the clinician. Some people need reinstruction in the sequence, and slow or unison practice is sometimes necessary for the task to be grasped. When the sequence cannot be learned, repetition of "buttercup, buttercup, buttercup . . ." is acceptable, but the meaningfulness of the word makes it a simpler task than /pʌtʌkʌ/.

4. *Contextual speech*—The most useful task for evaluating the integrated function of all components of speech, and each of the primary valves, is contextual speech. This includes conversational and narrative speech, as well as reading aloud a standard paragraph containing a representative phonetic sample. The well-known Grandfather Passage is often used for this purpose (see Appendix B).

Conversational speech is elicited during history taking, but the clinician's formal identification of deviant speech characteristics may be deferred so the facts of the history can be attended to. Open-ended questions about the patient's family, work, or hobbies usually elicit a sample sufficient to judge speech characteristics, but sometimes personality traits, depression, anxiety, or cognitive deficits limit responsiveness. Some people respond more readily with narratives about pictured scenes than to more open-ended inquiries.

Reading a standard passage can provide a good sample of connected speech, but adults' ability to read aloud varies widely. Less skilled readers may read slowly, hesitantly, and with pronunciation errors and prosodic features that are inconsistent with their conversational prosody. When such problems are pronounced, reading can be misleading or of little value.

5. *Stress testing*—People with MSDs are susceptible to the effects of fatigue. In fact, regardless of dysarthria type, they often complain of speech deterioration with prolonged conversation or with general physical fatigue over the course of a day. These complaints are obviously important to management issues, but because fatigue is so common it is usually unnecessary to observe its effects on speech for diagnostic purposes. However, whenever LMN weakness of unknown cause is present, or when the patient complains of rapid or dramatic changes in speech with continued speaking or general physical effort, speech stress testing should be pursued.

To assess fatigue, the patient should be asked to read aloud naturally or count as precisely as possible at a rate of about two digits per second. This should be continued without rest for 2 to 4 minutes. Significant deterioration of voice quality, resonance, or articulation consistent with perceptual characteristics associated with weakness may reflect the presence of myasthenia gravis, especially if speech then improves significantly after a minute or two of rest. Testing speech muscle

strength before and after stress testing may provide confirmatory evidence of weakness.

6. *Assessing motor speech planning or programming capacity*—Sometimes people produce distorted articulatory substitutions, omissions, repetitions, or additions. They may block, hesitate, or engage in trial-and-error groping for correct articulatory postures during conversation or reading. When this occurs, or when dominant hemisphere pathology is suspected, further assessment of speech motor planning or programming ability should be pursued. An apraxia of speech may be present.

If speech is mildly to moderately impaired, the patient should be asked to perform speech SMRs and to repeat complex multisyllabic words and sentences. Box 3-3[45] provides a list of stimuli that have proven useful for this purpose.

If the patient is mute or barely able to speak, tasks that facilitate speech or place minimal demands on novel motor planning or programming should be used. These tasks include singing a familiar tune, counting, saying the days of the week, completing redundant sentences, and imitating consonant-vowel-consonant (CVC) syllables with identical initial and final consonants. Sometimes, but not invariably, people find it easier to imitate isolated sounds than syllables or words. People with apraxia of speech may respond to these simple tasks with greater ease, making the salient auditory perceptual features of their apraxia more evident. A mismatch between ease of response on complex voluntary tasks versus simpler "automatic" tasks increases the likelihood that apraxia of speech and not dysarthria is the correct diagnosis.

Published Tests for the Diagnosis of Dysarthria

There is only one published test that quantifies distinctions among dysarthria types. A few published measures are available for assessing intelligibility in dysarthria, but they are not intended to establish the presence or type of dysarthria.

The only published diagnostic test is the *Frenchay Dysarthria Assessment (FDA)*.[14] The FDA relies on a rating scale applied to patient-provided information, observations of nonverbal oral structures and functions, and speech. Measures of intelligibility and speaking rate are also made, as well as judgments about hearing, vision, dentition, language, mood, posture, and sensation. The task-oriented portion of the test focuses on reflexes, speech and nonspeech activities of respiration, the lips, jaw, soft palate, tongue and larynx, and the measurement of intelligibility (the intelligibility portion of the test is discussed in the section on intelligibility assessment). The FDA is brief and does not require extensive training to administer and score.

Interjudge reliability coefficients for the test are acceptably high after 3 hours of training. It appears that the test distinguishes among flaccid, spastic, ataxic, hypokinetic, and mixed flaccid-spastic dysarthria with a high degree of accuracy. For example, a discriminant analysis of results for 85 patients with neurologic diagnoses consistent with sites of damage associated with each of the five dysarthria types correctly classified 91% of the patients. Correct classification across dysarthria types ranged from 83% to 100%. The test manual also indicates that an "independent diagnosis" based only on FDA profiles—not direct observation of patients—was in agreement with patients' therapists for 91% of 112 dysarthric patients.

The test manual provides graphs of the means and standard deviations for each of the dysarthria types examined (three of the five groups had fewer than 15 patients). It is clear that there is considerable overlap among the dysarthria types for many of the FDA subtests. Criteria for objectively determining dysarthria type are not provided, nor are the discriminant function formulas that would permit subject placement into a dysarthria category prospectively.

The FDA demonstrates that distinctions among patients with different dysarthria types can be quantified and that the distinctions correlate with neurologic diagnosis. The test relies heavily on patient report and ratings of nonspeech oral activities, and it does not yield a comprehensive description of specific deviant speech characteristics associated with each dysarthria type. For these reasons, it may be viewed most appropriately as a test that distinguishes among patients with different lesion loci on the basis of nonverbal oral findings and certain speech characteristics, rather than a differential diagnostic test of the auditory perceptual features of dysarthria per se. However, with the addition of data for other dysarthria types (e.g., hyperkinetic dysarthrias), an increase in the number of cases per type to the database and discriminant analyses, and provision of discriminant function formulas or other criteria for quantitatively determining dysarthria type for individual patients, the FDA could have increased value as a diagnostic measure of dysarthria.

Published Tests for the Diagnosis of Apraxia of Speech

The only currently available published measure for the assessment of apraxia of speech is the *Apraxia Battery for Adults—Second Edition (ABA-2)*.[7] The

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box 3-3   Tasks for assessing speech planning or programming capacity (apraxia of speech)

The tasks below require imitation or speaking in response to simple requests. Other tasks that are useful and important for assessing motor programming ability include conversation, narrative picture description, and reading aloud.

Scoring: The following codes may be used to capture response characteristics that may reflect apraxic behaviors.

Distortion (D)	Awareness of errors (AOE)
Groping (audible or visible) (G)	Slow rate (SR)
Distorted substitution (DS)	Syllable × segregation within multisyllabic words, phrases (S × S)
Attempts at articulatory self-correction (SC)	
Delayed response initiation (DR)	

A numeric code, adapted from the *Porch Index of Communicative Ability*,[36] may also be useful.

15 = correct in all respects	6 = error unrelated to target
14 = distorted	5 = rejection or stated inability to respond
13 = delayed to respond	4 = unintelligible but differentiated from other responses
10 = self-corrected articulatory	3 = unintelligible & relatively undifferentiated from other responses
9 = correct after a stimulus response repetition	
7 = error clearly related to target	

Broad or narrow transcription of responses can be helpful.

I. "Repeat these sounds after me"

1. /i/ _____	11. /k/ _____
2. /a/ _____	12. /g/ _____
3. /u/ _____	13. /s/ _____
4. /ei/ _____	14. /f/ _____
5. /ai/ _____	15. /tʃ/ _____
6. /au/ _____	
7. /m/ _____	
8. /p/ _____	
9. /t/ _____	
10. /n/ _____	

II. "Repeat these words after me"

1. mom _____	11. zoos _____
2. Bob _____	12. church _____
3. peep _____	13. shush _____
4. bib _____	14. lull _____
5. tot _____	15. roar _____
6. deed _____	
7. kick _____	
8. gag _____	
9. fife _____	
10. sis _____	

III. "Repeat these words"

1. cat _____
catnip _____
catapult _____
catastrophe _____
2. please _____
pleasing _____
pleasingly _____
3. thick _____
thicken _____
thickening _____

IV. "Repeat these words three times"

1. animal _____ _____ _____
2. snowman _____ _____ _____
3. artillery _____ _____ _____
4. stethoscope _____ _____ _____
5. rhinoceros _____ _____ _____
6. volcano _____ _____ _____
7. harmonica _____ _____ _____
8. specify _____ _____ _____
9. statistics _____ _____ _____
10. aluminum _____ _____ _____

V. "Repeat these sentences"

1. We saw several wild animals. _____
2. My physician wrote out a prescription. _____
3. The municipal judge sentenced the criminal. _____

VI. "Repeat as fast and as steadily as possible"

1. /pʌpʌpʌpʌ . . ./ _____	3. /kʌkʌkʌkʌ . . ./ _____
2. /tʌtʌtʌtʌ . . ./ _____	4. /pʌtʌkʌpʌtʌkʌ . . ./ _____

VII. "Count from 1 to 10"

1. _____	6. _____
2. _____	7. _____
3. _____	8. _____
4. _____	9. _____
5. _____	10. _____

VIII. "Say the days of the week"

1. Sunday _____	5. Thursday _____
2. Monday _____	6. Friday _____
3. Tuesday _____	7. Saturday _____
4. Wednesday _____	

IX. "Sing" ("Happy Birthday," "Jingle Bells," or another familiar tune)

1. How well is the tune carried? _____
2. How adequate is articulation? _____

X. Description of conversation and narrative speech. _____

XI. Description of reading aloud. _____

Modified from Wertz RT, LaPointe LL, Rosenbek JC: *Apraxia of speech: the disorder and its treatment,* New York, 1984, Grune & Stratton and unpublished Mayo Clinic tasks for assessing apraxia of speech.

ABA-2 was developed to "verify the presence of apraxia in the adult patient and to estimate the severity of the disorder,"[7] as well as to assist in designing treatment and documenting progress. It contains six subtests, five of which focus on speech or speech-related responses; the sixth subtest assesses limb and nonverbal oral apraxia. The subtests related to speech include (1) diadochokinetic rates for one-, two-, and three-syllable combinations; (2) imitation of words of increasing length; (3) latency and utterance time for naming of pictured multisyllabic words; (4) articulatory adequacy during three consecutive repetitions of polysyllabic words; and (5) an inventory of 15 behaviors or findings based on spontaneous speech, reading, and counting that the author associates with apraxia of speech. It should be noted that not all of the characteristics listed as apraxic in the inventory are unique to the disorder (i.e., some may also occur as manifestations of aphasia), and some may not be characteristic of apraxia of speech at all.

The test was standardized on a sample of 40 persons with apraxia and 49 people with normal speech. Cutoff scores are provided for determining the presence and level of impairment, and guidance is provided for recognizing and interpreting "atypical profiles." Guidance is also provided about treatment planning. The test manual presents data that led to a conclusion that the test is a reliable and valid measure of apraxia, but there are some shortcomings in this regard. For example, test-retest, intrajudge, and interjudge reliability are not reported, and data comparing apraxic to aphasic and dysarthric performance are based on small numbers of aphasic and dysarthric speakers. The latter shortcoming introduces uncertainty about the test's ability to distinguish apraxic from aphasic and dysarthric performance.

The ABA-2 can be administered in a standard fashion to patients with diagnosed or suspected apraxia of speech. Scores can be used to describe patient performance, compare performance over time, and perhaps quantify the diagnosis and severity of the problem. Reliability and validity have not been completely established. Regarding its diagnostic value, the test would benefit from a comparison with some standard for diagnosis. Because there is no other well-established, standardized test for apraxia of speech, judgments by experienced clinicians who agree on clinical criteria for diagnosis should probably represent the "gold standard" for examining this aspect of test validity.

Assessment of Intelligibility, Comprehensibility, and Efficiency

The impact of an MSD on the ability to communicate can be estimated through judgments or measures of intelligibility, comprehensibility, and efficiency. The next few paragraphs rely heavily on the work of Yorkston, Strand, and Kennedy[49] and Yorkston et al.[50] to discuss these concepts. When intelligibility (I), comprehensibility (C), and efficiency (E) are discussed collectively in subsequent paragraphs, they are referred to as *ICE.*

Intelligibility is the degree to which a listener understands the acoustic signal produced by a speaker. In people with MSDs, estimates of intelligibility reflect the acoustic accomplishment of the impaired speech system plus strategies used by the speaker to improve speech production.

Comprehensibility is the degree to which a listener understands speech on the basis of the acoustic signal plus all other information that may contribute to understanding what has been said. The additional information is independent of the acoustic signal and includes knowledge of the topic, semantic and syntactic context, the general physical setting, gestures and signs, orthographic cues, and so on.

Efficiency refers to the rate at which intelligible or comprehensible information is conveyed. It is an important supplement to measures of intelligibility and comprehensibility because it contributes to both the perception of speech normalcy and the normalcy of communication (by whatever means) in social contexts. For example, some people with MSDs are highly intelligible but very inefficient because speech rate is markedly slow; the severity of an MSD is greater in someone with moderately reduced intelligibility and slow rate than someone with comparable intelligibility and normal rate. Some people with MSDs can convey messages using speech and supplemental strategies that are highly comprehensible but so time consuming that their social "success" is limited.

The distinction between intelligibility and comprehensibility is important for at least two practical reasons. First, it tells us that estimates of intelligibility (and its efficiency) are a more valid measure of the functional limitations imposed by MSDs (i.e., the ability to speak normally), whereas estimates of comprehensibility (and its efficiency) are a more valid measure of the disability imposed by MSDs in social, communicative contexts. As a result, intelligibility and comprehensibility (and their efficiency) are distinct ways to describe severity.

The second reason follows from the first. If treatment focuses on reducing impairment or functional limitations imposed by an MSD (i.e., improving the acoustic signal), then intelligibility and its efficiency become the most valid, practical index of change. If treatment focuses on reducing disability (i.e., by also positively manipulating variables independent of the acoustic signal), then comprehensibility and its efficiency become the most valid, practical index of change.

When an MSD is mild, intelligibility and comprehensibility may be unaffected. In fact, MSDs are sometimes so mild that even efficiency, at least from a functional standpoint, also is not compromised. Nevertheless, ICE should always be addressed, because it has great face and ecologic validity as indices of severity. These assessments can range from subjective estimates during interaction with the patient to formal, standardized, quantitative testing.

The degree to which assessment of ICE is pursued depends on the purposes of examination. If the primary purpose is to diagnose or determine the need for treatment, general ratings of ICE can suffice. Such ratings may include judgments by the patient, significant other, and the clinician. The patient and significant other can be asked if ICE is a problem, how frequently and under what circumstances, and what is generally done to ensure a message is understood (e.g., repetition, yes-no questioning, writing). The clinician may estimate a percentage of intelligible or comprehensible speech based on observations during examination, noting the circumstances under which the judgment is based (e.g., in quiet, with visual contact, when the topic of conversation is known). An estimate of intelligibility or comprehensibility in other (usually less ideal) situations may also be made. Table 3-4 contains a scale that we have found reliable and useful for estimating intelligibil-

table 3-4	Intelligibility rating scale for motor speech disorders	
Rating	**Dimension**	**Intelligibility is . . .**
10	Environment*	Normal in all environments
	Content[†]	without restrictions on content
	Efficiency[‡]	without need for repairs
9	Environment	Sometimes[§] reduced under adverse conditions
	Content	when content is unrestricted
	Efficiency	but adequate with repairs
8	Environment	Sometimes reduced under ideal conditions
	Content	when content is unrestricted
	Efficiency	but adequate with repairs
7	Environment	Sometimes reduced under adverse conditions
	Content	even when content is restricted
	Efficiency	but adequate with repairs
6	Environment	Sometimes reduced under ideal conditions
	Content	when content is unrestricted
	Efficiency	even when repairs are attempted
5	Environment	Usually[¶] reduced under adverse conditions
	Content	when content is unrestricted
	Efficiency	even when repairs are attempted
4	Environment	Usually reduced under ideal conditions
	Content	even when content is restricted
	Efficiency	but adequate with repairs
3	Environment	Usually reduced under adverse conditions
	Content	even when content is restricted
	Efficiency	even when repairs are attempted
2	Environment	Usually reduced under ideal conditions
	Content	even when content is restricted
	Efficiency	even when repairs are attempted
1		Speech is not a viable means of communication in any environment, regardless of restrictions in content or attempts at repair

*Environment may be "ideal" (e.g., face-to-face, without visual or auditory deficits in the listener, without competition from noise or visual distractions) or "adverse" (e.g., at a distance, with visual or auditory deficits or distractions).
[†]Content may be "unrestricted" (includes all pragmatically appropriate content, new topics, lengthy narratives, etc.) or "restricted" (e.g., limited to brief responses to questions or statements that permit some prediction of response content).
[‡]Efficiency may be "normal" (rarely in need of repetition or clarification because of poor speech production) or "repairs" may be necessary (repetition, restatement, responses to clarifying questions, modified production such as oral spelling, word-by-word confirmation of listener's repetition, spelling, etc.)
[§]Intelligibility is reduced in 25% or less of utterances.
[¶]Intelligibility is reduced in 50% or more of utterances but not for all utterances.
Note: Not all combinations of deviant dimensions can be captured by a 10-point scale, and there is an obvious gray area between the meaning of "sometimes" and "usually." The point on the scale that most closely approximates the clinician's judgment should be used. Many patients may fit into more than one point on the scale. It is appropriate to assign a range rather than a single point in such cases (e.g., 5-6).

ity that also considers contributions from variables related to comprehensibility, such as speaking environment and message complexity or predictability.

Although comprehensibility of dysarthric speech has been studied, standardized tests for its assessment have not been developed. Measures of intelligibility have received more attention and are therefore emphasized here.

A quantitative estimate of intelligibility can be valuable as a baseline measure when the patient will be treated to improve intelligibility; when an objective, quantified estimate of severity must be made for medical-legal purposes; when treatment may not be pursued but when the patient is to be followed over time to document improvement, stability, or deterioration as a function of medical or surgical intervention, disease progression, and so on; or for research purposes.

Only a few measures have been developed for assessing intelligibility in adult dysarthric speakers. Virtually none have been designed specifically for apraxia of speech, although some of those available for dysarthria can probably be adapted for patients with apraxia of speech if aphasia is not a significant problem.

Assessment of Intelligibility in Dysarthric Speakers (AIDS)[46]

For many years, the AIDS has been the most widely used standardized test for measuring intelligibility, speaking rate, and communicative efficiency in people with dysarthria. It quantifies intelligibility of words and sentences and provides an estimate of communication efficiency by examining the rate of intelligible words per minute in sentences. The single word task requires the patient to read or imitate 50 words randomly selected from among 12 phonetically similar words for each of the 50 items. A judge listens to an audio recording of the responses and identifies the spoken words in a multiple-choice format in which the 12 choices for each word are listed or in a transcription format in which the spoken word is transcribed. The intelligibility score is the percentage of words identified correctly.

In the sentence task, the patient reads or imitates two sentences each, of 5 to 15 words in length, for a total of 220 words. Sentences are selected randomly from a master pool of 100 sentences of each length. The judge transcribes the sentences word by word. The intelligibility score is the percentage of words transcribed correctly.

At least two people must be involved in assessment, one to select the sample for assessment and the other to listen and transcribe or respond in a multiple-choice format to the recorded sample. Repeated assessments for a given patient over time must either

use the same judge or groups of judges to control for interjudge variability.

A measure of speaking rate during the sentence task is derived by dividing the number of words (220) by the duration of the sentence sample. Rate of intelligible speech is the number of correctly transcribed words divided by the total duration; a similar measure for rate of unintelligible words can also be computed. The rate of intelligible speech per minute is then divided by 190 (the mean rate of intelligible speech produced by normal speakers on the test, who are nearly 100% intelligible), yielding a *communicative efficiency ratio*. This measure may be particularly useful for mildly impaired speakers whose rate may be slow in spite of good intelligibility.[47]

The AIDS provides an index of severity of impairment, an estimate of the patient's deviation from normal, and a standard for monitoring change over time. Test-retest variability for the word-list test, allowing for differences between stimuli and day-to-day variability, is less than 5%. Variability between sentence lists for the sentence test, however, even within the same day, is higher (approximately 9% to 11%). This latter degree of variability led Yorkston and Beukelman to recommend establishment of stable baseline measures of intelligibility before starting intervention, if the test is to be used to help document treatment effects.

Sentence Intelligibility Test (SIT)[48]

The SIT is an updated Windows version of the sentence portion of the AIDS. It offers a considerable improvement over its predecessor relative to stimulus selection, automaticity and speed of scoring, and data storage.

The SIT is based on the same principles of testing as the AIDS, and it uses the same basic computations to yield measures of intelligibility, rate of intelligible speech, and efficiency. The software package allows for administration, scoring, and storage of results. The program will randomly select 22 or 11 (short version) stimulus sentences from a pool of 1100 sentences ranging from 5 to 15 words in length. The speaker is recorded while reading or imitating the selected sentences. As is the case for the AIDS, the examiner administering the test and the judge transcribing responses must be different people. The computer program computes all relevant scores based on the judge's transcription and marking of timing data.

Several indices of interjudge reliability are provided in the test manual, and they indicate that dispersion of intelligibility and intelligible words per minute scores within a 10% to 20% range fell in the 83% to 100% range, with interjudge correlations all

exceeding 0.9. Correlations between scores for different performances by the same speaker also all exceeded 0.9.

Frenchay Dysarthria Assessment (FDA)[14]

The FDA (already discussed) has a component that evaluates the intelligibility of words, sentences, and conversation. In the word task, 10 stimuli are drawn randomly from a set of 50 words. The 10 words, unknown to the examiner, are read by the patient. Performance on the task is rated on a 5-point scale with points on the scale reflecting differences in the number of words correctly recognized or the ease with which they are recognized. Although some of the words on the 50-item list are distinguished by minimal contrasts (park, dark), the 50 stimuli are heterogenous in frequency of occurrence, number of phonemes and syllables, and stress pattern. This word heterogeneity causes problems in selecting equivalent lists, and the intervals between points on the 5-point rating scale may not be equal.[32]

The sentence task is administered and scored like the word task. The sentences actually consist of a standard carrier phrase "the man is" with the final word represented by one of 50 randomly selected words ending with "ing." This task is thus more a measure of single word intelligibility within a sentence context than sentence intelligibility per se.

The conversation task is based on about 5 minutes of conversation that is graded on a 5-point severity scale ranging from "no abnormality" to "totally unintelligible" speech. Although the scale represents a ranking of impaired intelligibility, its quantitative value is limited.

A Word Intelligibility Test

Kent et al.[32] have designed two word intelligibility tests for use with dysarthric speakers. Although not published as standardized tests, they deserve mention because they provide clinically useful information beyond percentage scores for intelligibility and efficiency.

Both tests are single word measures. An intelligibility score representing percentage of intelligible words is generated by judgments of words read by a speaker. The word stimuli and organization of response choices permit examination of 19 phonetic contrasts that may be vulnerable in dysarthria (e.g., front-back vowel contrasts, voicing contrasts for initial and final consonants, fricative-affricate contrasts). The phonetic contrasts have acoustic correlates (e.g., voice onset time and preceding vowel duration for initial and final voicing contrasts, respectively), which permit a more in-depth exploration of features associated with decreased intelli-

gibility. The phonetic feature analysis extends perceptual findings by identifying the effect on articulation or phonetic outcomes of laryngeal and velopharyngeal dysfunction.[32]

In the multiple-choice version, the speaker reads one of four words distinguished by minimal phonetic contrasts (e.g., beat, boot, bit, meat). There are 70 minimal contrast items in the test and any of the four contrasting words for each item can be used (e.g., there are 280 test words). This allows random selection of one of the four words for each of the 70 items, so repeated assessments may be conducted with the same judges.

The paired-word version is designed for use with severely dysarthric patients who cannot reliably produce more complex CVC syllables. Its items consist almost entirely of minimal contrasts within CV or VC syllables (e.g., shoe-chew, eat-it). Sixteen contrasts are tested in three word pairs each.

The test's ability to quantify intelligibility and identify the locus of phonetic difficulties that contribute most to reduced intelligibility has been documented for adults with ataxic, hypokinetic, and various mixed dysarthrias associated with several neurologic diseases (e.g., amyotrophic lateral sclerosis [ALS], cerebral palsy, stroke, parkinsonism, and multiple sclerosis).[1,6,25,28,31,32] The information about the phonetic contributors to reduced intelligibility provided by the test could aid decisions about treatment focus and, possibly, diagnosis. Because the phonetic contrasts examined in the test have measurable acoustic counterparts, test results may also influence the choice of relevant acoustic analyses for individual speakers or specific dysarthria types. These combined attributes have the potential to refine perceptual analyses, direct acoustic and physiologic analyses, document severity, guide emphasis in treatment, and perhaps establish distinctive patterns of phonetic deficits associated with specific dysarthria types.

SUMMARY

1. Diagnosis of MSDs depends on adequate examination of speech and the speech mechanism. Examination includes description, establishing diagnostic possibilities, establishing a diagnosis, establishing implications for localization and disease diagnosis, and specifying severity.

2. The essential components of the motor speech examination include the history; examination of the oral mechanism; assessment of salient features of speech; estimation of intelligibility and severity; and, when appropriate, acoustic and physiologic measures.

3. The history requires goal setting with the patient and acquiring information about relevant events before the onset of speech deficits, the onset and course of the speech problem, the course and nature of associated deficits, the patient's perception of the speech problem and its consequences, current or prior management of the speech problem, and the patient's awareness of the medical diagnosis and prognosis.

4. Speech assessment relies heavily on identification of deviant speech characteristics. Speech tasks include vowel prolongation, AMRs, SMRs, contextual speech, stress testing, and tasks for stressing or facilitating motor speech programming. Accurate diagnosis ideally relies on an analytic approach in which deviant speech characteristics and clusters are identified, plus a synthetic appreciation of the "global" product of all speech characteristics interacting with one another.

5. Examination of the oral mechanism at rest and during nonspeech activities provides confirmatory evidence and information about the size, strength, symmetry, range, tone, steadiness, speed, and accuracy of orofacial structures and their movements. Observations of speech structures are made at rest, during sustained postures and movement, and in response to reflex testing. Assessing volitional versus automatic nonspeech movements of the speech muscles is also important when nonverbal oral apraxia is suspected.

6. Assessments of the intelligibility, comprehensibility, and efficiency of speech serve as indices of the impact of MSDs on the ability to communicate, and as indices of change over time. They can be estimated through clinical judgments or quantitative measures. Estimates of intelligibility reflect the functional impact of MSDs, by themselves, on spoken communication, whereas estimates of comprehensibility reflect the degree of disability imposed by MSDs, allowing for the contribution that information from nonspeech modalities and strategies make to the understanding of speech.

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A Deviant Speech Dimensions Encountered in Dysarthrias

LABEL	DESCRIPTION
Mayo Clinic Dysarthria Study Dimensions	
1. Pitch level	Pitch of voice sounds consistently too low or too high for age and sex.
2. Pitch breaks	Pitch of voice shows sudden and uncontrolled variation (falsetto breaks).
3. Monopitch	Voice is characterized by a monopitch or monotone. Voice lacks normal pitch and inflectional changes. It tends to stay at one pitch level.
4. Voice tremor	Voice shows shakiness or tremulousness.
5. Monoloudness	Voice shows monotony of loudness. It lacks normal variations in loudness.
6. Excess loudness variation	Voice shows sudden, uncontrolled alterations in loudness, sometimes becoming too loud, sometimes too weak.
7. Loudness decay	There is progressive diminution or decay of loudness.
8. Alternating loudness	There are alternating changes in loudness.
9. Loudness level (overall)	Voice is insufficiently or excessively loud.
10. Harsh voice	Voice is harsh, rough, and raspy.
11. Hoarse (wet) voice	There is wet, "liquid-sounding" hoarseness.
12. Breathy voice (continuous)	Voice is continuously breathy, weak, and thin.
13. Breathy voice (transient)	Breathiness is transient, periodic, and intermittent.
14. Strained-strangled voice	Voice (phonation) sounds strained or strangled (an apparently effortful squeezing of voice through glottis).
15. Voice stoppages	There are sudden stoppages of voice air stream (as if some obstacle along vocal tract momentarily impedes flow of air).
16. Hypernasality	Voice sounds excessively nasal. Excessive amount of air is resonated by nasal cavities.
17. Hyponasality	Voice is denasal.
18. Nasal emission	There is nasal emission of air stream.
19. Forced inspiration-expiration	Speech is interrupted by sudden, forced inspiration and expiration sighs.
20. Audible inspiration	There is audible, breathy inspiration.
21. Grunt at end of expiration	There is a grunt at the end of expiration.
22. Rate	Rate of actual speech is abnormally slow or rapid.
23. Short phrases	Phrases are short (possibly because inspirations occur more often than normal). Speaker may sound as if he or she has run out of air. Speaker may produce a gasp at the end of a phrase.
24. Increase of rate in segments	Rate increases progressively within given segments of connected speech.
25. Increase of rate overall	Rate increases progressively from beginning to end of sample.
26. Reduced stress	Speech shows reduction of proper stress or emphasis patterns.
27. Variable rate	Rate alternates from slow to fast.
28. Prolonged intervals	There is prolongation of interword or intersyllable intervals.

LABEL	DESCRIPTION
29. Inappropriate silences	There are inappropriate silent intervals.
30. Short rushes of speech	There are short rushes of speech separated by pauses.
31. Excess and equal stress	There is excess stress on usually unstressed parts of speech (e.g., monosyllabic words, unstressed syllables of polysyllabic words).
32. Imprecise consonants	Consonant sounds lack precision. They show slurring, inadequate sharpness, distortions, and lack of crispness. There is clumsiness in going from one consonant sound to another.
33. Prolonged phonemes	There are prolongations of phonemes.
34. Repeated phonemes	There are repetitions of phonemes.
35. Irregular articulatory breakdowns	There is intermittent, nonsystematic breakdown in accuracy of articulation.
36. Distorted vowels	Vowel sounds are distorted throughout their total duration.
37. Intelligibility (overall)	This is a rating of overall intelligibility or understandability of speech.
38. Bizarreness (overall)	This is a rating of degree to which overall speech calls attention to itself because of its unusual, peculiar, or bizarre characteristics.

Other Relevant Dimensions (Not Rated in the Mayo Clinic Dysarthria Studies by Darley, Aronson, and Brown)

39. Diplophonia	Simultaneous perception of two different pitches
40. Flutter	Rapid, relatively low-amplitude voice tremor (perceived as in the 7-12 Hz range), usually most apparent during vowel prolongation.
41. Inhalatory stridor	Similar to audible inspiration (#20) but characterized by actual rough phonation due to vocal fold approximation and oscillation during inhalation.
42. Myoclonus	1-4 Hz rhythmic tremorlike "beats" in the voice, sometimes sufficient to cause brief voice arrests, usually heard only during vowel prolongation.
43. Weak pressure consonants	Pressure consonants lack acoustic distinctiveness or are weak because of excessive nasal airflow during their production.
44. Slow AMRs or fast AMRs	Speech AMRs are slow or fast.
45. Irregular AMRs	Speech AMRs are irregular in duration, pitch, or loudness.
46. Simple vocal tics	Repetitive, rapid, apparently involuntary noises or sounds (e.g., throat clearing, grunting) produced in isolation or during voluntary speech.
47. Palilalia	Compulsive repetition of words or phrases, usually in a context of accelerating rate and decreasing loudness.
48. Coprolalia	Involuntary, compulsive, repetitive obscene language or swearing, uttered loudly, softly, or incompletely.

Permission of Darley FL, Aronson AE, Brown JR: *Motor speech disorders*, Philadelphia, 1975, WB Saunders.
AMRs, Alternating motion rates.

B Grandfather Passage

You wish to know all about my grandfather. Well, he is nearly 93 years old, yet he still thinks as swiftly as ever. He dresses himself in an old black frock coat, usually with several buttons missing. A long beard clings to his chin, giving those who observe him a pronounced feeling of the utmost respect. Twice each day he plays skillfully and with zest upon a small organ. Except in the winter when the snow or ice prevents, he slowly takes a short walk in the open air each day. We have often urged him to walk more and smoke less, but he always answers, "Banana oil!" Grandfather likes to be modern in his language.

Number of words = 115

Approximate time to read aloud by normal speakers with normal reading skills = 35 to 45 seconds.