"Communication Disorders." Encyclopedia of Educational Psychology. 2008. SAGE Publications.

Communication Disorders

The ability to communicate using speech is one of the most effortless, taken-for-granted human faculties. Its importance, however, becomes readily apparent when

Speech Production Process

Generally, three stages in the central brain processes are posited prior to production of speech. Each stage can be conceived of as a neural activation pattern that evolves and morphs at a fast pace into a pattern associated with the succeeding stage. The foregoing description suggests that the stages are organized serially, that is, processing in one stage is completed before the processing in the succeeding stage begins. However, there is evidence to suggest that processes in the stages and within each stage are part serial and part parallel. Thus, for example, fitting words in proper grammatical slots in a sentence does not occur one word at a time from beginning to the end but in parallel. This view is supported by a variety of slips of tongue data (e.g., **Intended**: *The map is in the car.* **Produced**: *The car is in the map*).

The first stage is thought processes leading to message formulation. Thought is language-neutral and, by symbolically representing thought using the vehicle of language, the message is made available to the conscious mind. This prelinguistic stage is generally conceived to be beyond the purview of communication sciences.

In the second stage, the message undergoes linguistic formulation. Linguistic formulation involves multiple processes such as selection of language to be used (if a speaker knows more than one language and the listener is equally competent in that language), the retrieval of words from the lexicon—long-term storage—to be fitted in a preselected sentence structure (syntactic frame) that specifies the linear order of parts of speech (grammatical categories) and phonological structure (i.e., how the sentence will sound).

The third stage is conceived to be motor planning of the linguistically formulated message. Motor planning is specification of timing and extent of muscle group contraction-relaxation in the peripheral organs involved in speech production. These organs, collectively referred to as the *speech production system*, compose the respiratory system, the laryngeal system, and the oro-nasal-pharyngeal system. The patterned muscular contraction-relaxations result in movement of ribs, lungs, vocal folds, velum (soft palate), jaw, tongue, and lips, all geared toward controlled expulsion of air and generation of sound using vocal folds, which in turn are shaped into a nearly concatenated series of overlapping sounds called speech. The motor plan reflects the sound- and word-specific movement requirements. Additionally, the motor plan also encodes for the effects the speaker intends the message to have on the listener. Thus, a speaker may state, persuade, seek to clarify, or seek clarification. These goals change the movement underlying a word sequence and hence the sound output. These changes are called *prosodic changes.* Prosodic changes can be illustrated by an example. A speaker may state "This book is interesting" or stress the word "This" to emphasize that this book, and not some other book, is interesting. In addition, the speaker may want to communicate enthusiasm, disgust, anger, irony, or approval. These affective components also contribute to changes in global and local acoustic features of the produced sentence. These changes are collectively referred to as *paralinguistic changes.*

A message repeated twice might not involve exactly the same motor plan. Motor plans are altered to respond to the current constraints on the speech mechanism. To take a simple example, to produce /p/ in the word "pat," the instructions to approximate the lips would differ depending on the current position of the lips. If the mouth is currently open, the muscles of the jaw as well as the lips will be involved in lip approximation. On the other hand, if the mouth is closed, the same target sound is achieved without the activity of jaw muscles. Peripheral sensory or afferent inputs inform central motor planning mechanisms about the existing constraints. In normal speech production, a rapid contextual adjustment is the rule rather than the exception. The use of different muscle groups to achieve the same acoustic/perceptual target is called *motor equivalence.* Motor equivalence underscores the principle that the brain uses variable means to achieve invariant ends.

The most important sensory signals arise from tactile (sense of touch) and proprioceptive mechanisms in the speech production system. They inform the motor planner about the constraints prior to initiation of speech. These feedback signals are supplemented with auditory feedback signals once speech begins.

Peripheral feedback is crucial during the early years of speech and language acquisition; their role in adult skilled speakers is still a matter that needs to be settled. Do skilled speakers depend on them all the time to monitor the progress of an utterance? There is ample evidence to show that they play a role in getting the production back on track if there is a sudden, unexpected perturbation to the speech production system. The relative importance of the type of feedback signal—auditory, tactile, or kinesthetic—is also an open question.

Respiratory, laryngeal, and oro-naso-pharyngeal structures have dual life-supporting functions: breathing and eating. Quiet breathing is automatic and governed by the respiratory centers in the medulla oblongata. During quiet breathing, durations of inspiration and expiration are nearly equal. While speaking, however, the duration of expiration is considerably increased in relation to the duration of inspiration. This change represents an active modification of expiratory muscle activity to generate a steady expiratory stream as a power source for speech.

The vocal folds in the larynx (commonly referred to as voice box) move to the midline to impede the expiratory breath stream. When the air pressure below the folds exceeds air pressure above the folds in the vocal tract (pharynx, oral and nasal cavities), the folds are forcefully opened and set in a periodic to-and-fro movement, generating a voice. By changing the degree of vocal fold approximation (or degree of impediment to the flow of air) and the folds' length and tension, a speaker can generate degrees of emphasis (stress) and pitch to achieve linguistic, prosodic, and paralinguistic goals.

The voice (sound) is transmitted and modified by changing configuration of the vocal tract. The various cavities of the vocal tract act as acoustic resonators. Continuous speech involves rapid changes in vocal tract configuration, which in turn engenders rapid changes in resonating characteristics. The changes in resonating characteristics, in large measure, underlie the distinction between serially organized speech sounds produced during continuous speech. Changes in vocal tract configuration are achieved by the movement of lips, jaw, tongue, and velum.

Language Processing and the Brain

It has been known that the left hemisphere of the brain is dominant for language processing in most individuals ever since Paul Broca's description of a patient with a lesion in the left inferior frontal cortex region of the brain. The patient had effortful speech with relative preservation of comprehension skills. The clinical data from patients with lesions in the left hemisphere show that there is a degree of modularity—the frontal lesions generally affecting flow of speech while preserving comprehension, whereas posterior lesions in the parietal lobe affect comprehension skills while preserving flow of speech. There have been considerable attempts to relate symptoms with sites of lesions, with some degree of success. However, correlating symptoms with sites does not reveal how a brain functions in a healthy individual when engaged in various language tasks. The glimpses of complexity of neural activity when the brain is engaged in such simple language processing tasks as naming pictures and matching an appropriate verb with a stimulus noun are being highlighted by modern neuroimaging techniques such as functional magnetic resonance imaging, positron emission tomography, and magneto-encephalography. Such techniques reveal that there are multiple regions of activations within the left language hemisphere and the nondominant right hemisphere.

Disorders arising during linguistic formulation are collectively termed *aphasia* or *dysphasia.* Thus, a patient may have a problem in retrieving lexical items or words (anomia) from the lexicon, a problem with syntactic processing (syntactic aphasia), or a problem in sequencing the phonemes (apraxia) that constitute individual words. Aphasia typically results from cerebrovascular accidents such as hemorrhage, embolism, and ischemia in the left hemisphere. Children may exhibit language formulation issues even without brain lesions.

Hearing and Speech Perception

The process of recovery of encoded messages starts in the peripheral hearing mechanism (ear). The ear has three distinct parts: external, middle, and inner. The acoustic energy in the ear canal is converted into mechanical energy of the intricate motion of the ear drum and the three middle ear ossicles (bones). This motion in turn produces vibration of fluid in the inner ear. The motion of the inner ear fluid results in the motion of the basilar membrane. The end organs (hair cells) of the auditory nerve are located on the basilar membrane. Different regions of the basilar membrane are responsive (resonate) to different frequencies. Hence, the inner ear activity results in spectral (frequency by intensity) analysis of speech in terms of patterned excitation in the auditory nerve. The patterned excitation reaches the primary auditory cortex in the temporal lobe of the brain where sound is sensed. The secondary auditory cortex surrounding the primary auditory cortex is involved in putting the analyzed signal back (fusion) to recover the literal message and then the intended message.

The aforementioned thumbnail sketch of the hearing process provides a strictly serial view of hearing and speech perception. However, speech perception, defined as recovery of the sequence of phonemes constituting an utterance, is anything but serial. At any given point in time, a listener is not only analyzing the speech but also bringing to bear on the analysis contextual and knowledge constraints to arrive at a decision regarding sound and word identity. Thus, speech perception involves both bottom-up processes (acoustic input analysis) and top-down processes (contextual and knowledge constraint inputs to the analysis). There is considerable evidence supporting the idea that as a listener begins processing a spoken word, the initial input (beginning of the word) activates a cohort of candidate words with that beginning. But as more and more of the spoken word unfolds, all the words are rejected (deactivated) in favor of the one the speaker intended. This is the idea behind Internet search engines with a search history—as an individual types a few beginning letters of a word, the system presents multiple candidate words beginning with the letter sequence. As the individual types more letters, more and more candidate words are rejected in favor of one the individual had used previously.

Communication Disorders in Educational Settings

Hearing Loss, Speech, and Language Development

Communication disorders can arise at any level of the communication process outlined above. An additional complication arises when communication disorders in educational settings are considered. Preschool and elementary school years are the years when children grow at a rapid pace physically, cognitively, and linguistically. There is a strong reason to believe that human children are biologically equipped to extract language from speech to which they are exposed. In essence, growing children implicitly acquire a system of rules (grammar) that will enable them, in Noam Chomsky's words, to understand and produce sentences that they have never heard before or produced before. However, there seems to be a critical period—roughly between birth and preadolescent years, and particularly between birth and 5 years—in which a child needs to be exposed to a language. A child's growth in other departments—cognitive, affective, and neuromuscular—must go hand in hand for a child to be an age-appropriate communicator.

The acquisition of language may be delayed in an otherwise normal child because of frequent middle-ear infections that result in temporary or permanent loss of hearing. The effect of frequent infections depends on whether the condition is unilateral or bilateral. Unilateral conditions typically do not affect language development; bilateral conditions do. The degree of hearing loss will have a direct impact on the phonological development—mastery of language-specific sound distinctions and word-specific changes that signify tense, number, and so on. A serious deficit in the middle-ear transmission function can result in a 30- to 50-decibel (dB) sound pressure level (SPL) loss in the speech signal strength. Normal face-to-face conversation is typically around 60dB SPL. In this condition, the child is barely hearing speech and is missing most of the consonants, which are shorter and less intense than vowels. These phonological problems can be remediated effectively by addressing the hearing problem—using a hearing aid to amplify sounds—and with speech therapy that creates awareness of sound distinctions and direct speech therapy.

The extreme case is children who do not hear at all due to diseases—congenital or acquired—that affect the inner-ear processing. There are degrees of sensorineural hearing losses, and accordingly, one can expect degrees of language delays and impairment. A severe inner-ear impairment is generally recognized by parents or a caregiver; less severe conditions may receive delayed identification. In these conditions, early diagnosis has a direct impact on the effectiveness of rehabilitative procedures. Teachers and caregivers must seek professional help if they suspect hearing loss. An ear, nose, and throat specialist or an audiologist is the most appropriate person to contact. Early identification is so critical for the development of speech and language that there is a need for infant hearing screening programs.

Specific Language Impairment

Specific language impairment (SLI) is a condition in which children are normal in all respects and have adequate exposure and opportunity for learning a language but still fall significantly behind their peers. The prevalence of SLI in the general population is around 7%. An SLI child scores normal or above normal on nonverbal intelligence tests and does not have hearing loss, brain damage, or any other physical abnormality that can explain significantly low performance on language tests. A few recover, but many continue to suffer. SLI is significantly correlated with reading impairment.

Most English-speaking SLI individuals exhibit a deficit in using bound morphemes that indicate past tense (walk-walk*ed*), more than one (book-book*s*), and done by someone (climb-climb*s*). Some investigators have suggested that an SLI child has difficulty processing brief, rapidly unfolding sounds as an explanation for language impairment. This explanation suggests that, at its roots, it is a perceptual problem.

Several lines of evidence suggest a genetic basis for the disorder: More males than females have SLI, there is aggregation of SLI in families at a rate beyond the general population rate, and there is greater concordance (i.e., both suffer) among identical twins rather than fraternal twins.

There has been an in-depth investigation of a family (KE family) that had significant aggregation of individuals with SLI. The aggregation pattern in a three-generation pedigree indicates a strong autosomal dominance pattern. The genes responsible for this particular family's disorders have been mapped to a particular area on chromosome 7, and genetic analysis of an unrelated patient who exhibited similar language problems revealed a mutation in this same region. Although further studies are necessary, it may be that this mutation leads to a lack of a particular protein that affects the development of neural structures important for speech and language, the way similar proteins have been shown to influence neuronal development in other organisms. Subsequent study using neuroimaging techniques confirmed anatomical abnormalities in certain localized regions of the brain. The imaging study involved comparisons of brain anatomy of impaired and unimpaired members of the family. The overall genetic pattern exhibited by the KE family, especially with the discovery of the gene deletion, strongly suggests that a gene, or a small set of genes, has a major impact on language development.

Current studies are attempting to classify SLI patients into distinct subgroups based on the details of their impairment so that testing can determine more precisely the causes of the impairment.

Fluency Disorders

There are a host of disorders that affect the smooth flow of speech during early childhood. The most notable among them is developmental stuttering (DS). DS is a perplexing problem generally considered to be triggered in postlinguistic formulation stages.

Developmental stuttering, as the name suggests, manifests itself during the early years of rapid physical, cognitive, and language development. It is characterized by involuntary intermittent disruptions that take the form of fragmentation and repetitions of the beginning of words, prolongation of the initial sound of the word, or inappropriate silence or blocks. The onset is typically gradual and usually occurs when children start putting words together in sentences. The lifetime incidence of the disorder is estimated to be 5%, with a 1% prevalence rate in the population. Because the incidence of stuttering decreases precipitously from 2 to 10 years, the disparity in lifetime incidence and prevalence suggests that many children (around 80%) recover spontaneously, and a few continue to stutter into adolescence and adulthood.

The current understanding of the disorder is that it is etiologically complex, that is, both nature (genetics) and nurture (environment) play a role. The arguments in favor of a genetic basis are that it is more prevalent in boys than girls, the prevalence of stuttering in families of stutterers is significantly more than in the general population, and the concordance for stuttering among identical twins is very high compared to fraternal twins. Recent studies have shown that an autosomal dominance model, influenced by the gender of the affected individual and the affection status of the parents, is the best fit for the aggregation pattern in families. Recent neuroimaging studies have shown significant anatomical and functional differences between the brains of adult stutterers and normal speakers. The studies are still preliminary.

For a long time, stuttering was considered to be caused by anxiety, or it was considered to be something a person could overcome if only he or she tried. As a disorder, it was imitated, with negative consequences for individuals who were being imitated. The current understanding is that at its inception, it is purely a speech motor problem, and that anxiety as a factor starts having an impact on the basic problem once the disorder develops. Many researchers are focused on finding how children who spontaneously recover differ from those who do not.

Stuttering in school-age children is a big concern. The effect of this disorder on self-concept, coupled with generally negative reactions from others in the child's immediate environment, alters the child's psychosocial life. Later, it may compel him or her to limit his or her choices in terms of vocation and avocation. It is essential that teachers seek an SLP's help, and the child should be helped in the context of a team involving an SLP, teacher, and parents.

Dysarthrias

There is a large group of disorders that results from neuromuscular impairment that may affect the speed, range, direction, strength, and timing of movements. These are due to either congenital or acquired lesions of the central nervous system. The speech symptoms can be mild or severe depending on the site and extent of the lesion. Children with dysarthrias exhibit imprecise articulation (sound production), an inability to control voice parameters such as loudness and pitch, and mis-timed speech movements. Dysarthrias occur independent of language processing disorders. Because the degree of impairment varies considerably, a thorough speech mechanism evaluation is a must to identify the problem and define the subtype of dysarthria before intervention can be planned.

Professional Training

This entry has highlighted a few communication disorders from a vast list. The field is enormous, and each disorder has an area of specialization. Diagnosis and treatment of communication disorders requires extensive training (a 4-year undergraduate program with communication sciences and disorders as a major) and a 2-year master's program followed by a year of clinical externship. Speech and language pathologists and audiologists must be certified by the American Speech-Language and Hearing Association before beginning to practice.

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See also Language Disorders; Speech Disorders

Further Readings

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