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AUDITION: COGNITIVE INFLUENCES

Audition is the ability to sense and perceive sound. Audition relies on bottom-up sensory mechanisms, which govern how the sound is changed from physical energy in the environment to electrical impulses used by the brain, and top-down cognitive perceptual mechanisms, which govern how we identify and interpret sounds. The ability to transduce sound is only one small part of audition because the cognitive abilities we bring to bear when listening are also important for auditory perception. For example, imagine that you are walking down a dark street at night and you hear the sound of a dog barking. A wealth of auditory information is available in the signal that will tell you about the dog and determine how you will react to it. Bottom-up processes will allow you to identify where the dog is located (in front or behind you; on your left or right), tell you about its proximity (near or far away), and whether the dog is outside in a yard (if the sound is clear and unobstructed) or inside a building (if the sound is muffled and filtered by the walls). However, top-down mechanisms will influence your perception of the auditory information and determine how you will react to the sound. Such mechanisms allow you to accurately identify the sound as being produced by a dog rather than some other source (a cat, or a person imitating a dog) and allow you to determine its size (small or large) or possibly its breed (such as a Bassett hound, Chihuahua, or Rottweiler). You may also be able to determine the mood of the dog (does it sound friendly or unfriendly? does it sound excited, sad, fearful, or aggressive?). If you have had bad experiences with dogs, you may interpret the sounds as being aggressive, eliciting a fear response. If you have had good experiences with dogs, the sound may elicit a more neutral or positive response. Even in the seemingly simple case of hearing a barking dog, a variety of cognitive processes are brought to bear when you interpret the auditory information and will ultimately determine your response. This entry describes adaptation, attention, and context of cognitive influences on audition, as well as perceptual learning and expertise.

Adaptation, Attention, and Context

From the previous example, we can see that top-down information can alter our perception of sound. The knowledge that a listener has about sound and how the listener uses that information is an important part of audition. The amount of attention that is required during listening and the context of the environment play central roles in altering our perception of sound. For example, you quickly adapt to the din of the conversations around you when in a noisy restaurant: Instead of hearing individual voices, you hear a rumbling babble in the background. Yet, occasionally a sound will emerge and become perceptually salient (such as when someone coughs loudly, or we hear our name being called). Adaptation to an environmental context will allow us to move our focus of attention from things that do not concern us (such as the conversation at the next table) to things that are more important (such as the other people at our table or hearing our own name). The ability to separate sound sources and focus attention on a particular source (in this case a specific talker) is central to our success in listening in noise and is determined by our cognitive abilities. Listening to speech in noise becomes much more difficult when we perform multiple tasks: when our attention becomes divided, we may not be able to devote enough conscious attention to a particular speaker and will not be able to understand the speaker as well. This is an especially challenging problem for people who are hearing impaired.

Hearing impairment (the loss of auditory sensitivity) is a significant problem for many people. Yet hearing loss can be difficult to diagnose because of conscious and unconscious adaptive strategies that people develop to understand spoken language. Individuals with mild hearing loss may not notice the loss of sensitivity because they devote more attention to auditory perception (next time you are at a party, notice how you are directing your attention when talking with someone). Many people with hearing loss even fill in missing parts of a conversation with highly predictable information based on the context of the discourse. Thus, attention (top-down) can make up for lack of auditory sensitivity (bottom-up). These adaptive strategies are remarkably successful, but will ultimately break down when the hearing loss becomes more severe. When the loss of auditory sensitivity becomes so advanced that a large amount of auditory information is unavailable, context and attention no longer provide a benefit. In such cases, a person may seek consultation with a hearing specialist and receive a diagnosis of hearing loss.

Another way in which top-down cognitive mechanisms and prior experience influence auditory perception comes from our familiarity with particular talkers. Although we may speak a common language, all talkers produce speech differently and the listener must rapidly and efficiently adapt to talkers on an individual basis. Talker familiarity can provide significant benefits when listening to speech in noise. Research has shown that individuals find talkers that they know more intelligible than unfamiliar talkers. In this case, the information that we have learned about a specific talker's voice (the talker's accent, dialect, idiosyncrasies in pronunciation, and speaking style) influences our auditory perception. In these examples, our perception is altered by what we know about a talker's voice and allows us to devote attention to those aspects that will be most useful under difficult listening conditions. Additionally, listeners have better memory for speech produced by familiar talkers compared with that of unfamiliar talkers, suggesting that familiar talkers may be afforded different status than are unfamiliar talkers. The power of such an exposure effect may be why many radio and TV commercials use voices of well-known celebrities without explicitly identifying them to promote a certain product: if the listeners are familiar with the voice of the speaker, they may pay more attention to and remember the message that the advertisers want to convey. Such indexical features (the acoustic properties of a speaker's voice that reflect his or her identity and condition, such as age, gender, size, health, dialect, etc.) can thus significantly alter our interpretation of speech.

The context under which we are listening is also particularly important for auditory perception because it will determine where we direct our attention and what "pops out" from the background. In certain environments, we would not expect to hear a certain sound and may differentially direct attention when an unexpected sound occurs. The sound of a police siren may indicate different things if you are sitting in your living room versus when it is behind you in traffic. The sound of a growling bear may mean one thing if you are at a zoo, but something completely different if you are on a hike in the woods. In both examples, the sounds are the same, but the way we perceive and interpret them and, hence, how we react to them will differ significantly because of context. A sound that may be perfectly mundane in one environment will become particularly salient when heard in a different context. Expectation can alter auditory perception in profound ways. Sine wave speech is a form of artificial speech that consists of three tones that vary in frequency, intensity, and rhythm as does the original speech signal. Yet, the perception of such stimuli depends on the instructions that the listener is given. If told that they are listening to birdsong, listeners will identify the stimulus as birdsong. However, if told that they are listening to computer-generated speech, listeners will perceive the signal as speech. In this case, the same identical stimulus can be heard in two different ways depending on the context in which we are listening. Similar top-down effects may be responsible for detecting subliminal messages in records when played backwards: If we expect to hear a secret message in "Stairway to Heaven," then that is exactly what we perceive.

Perceptual Learning and Expertise

Perceptual learning plays a central role in auditory cognition and is especially important when learning about sound. Auditory perceptual learning is caused by exposure to and familiarity with sound and will alter our perception of sound in the future. From a young age, children are encouraged to identify sources of sound in their environment. Whether playing with toys that match a sound with a picture of the source that produced it (e.g., the sound of a cow with the picture of a cow), children are constantly refining their cognitive abilities through interactions with their environment. Understanding the sources of sounds is especially important for survival because the sounds that surround us contain information that will help to determine what actions are most appropriate. Alerting signals in the environment can indicate situations that require our attention. The sound of a smoke detector or car horn may alert us to impending danger, prompting us to react. Yet, the perception of environmental sounds is not limited to simple alerting functions. Returning to our example of the barking dog, a person who has extensive experience with dogs may interpret the sound differently than does someone who does not have much experience with dogs. Experience with sounds alters the number of dimensions that we can use to classify the sounds. A person who has grown up having dogs as pets may be able to hear many different things in the sound of a barking dog compared with a person who is unfamiliar with dogs. Through their past experience with a sound, its perceptual dimensionality (the number of different dimensions on which a sound can be classified) has increased. This is especially salient for auditory experts.

Auditory expertise comes from practice and experience. Many auditory experts perceive sound differently than do nonexperts. For example, a skilled auto mechanic may be able to listen to the sound of an idling engine and diagnose what is wrong with a vehicle. Similarly, cardiologists may be able to listen to our breathing or the beating of our hearts and determine our relative health. Parents may be able to listen to the cries of a baby and determine whether the baby is hungry, lonely, needs to be changed, or is in distress. In all of these examples, auditory expertise and experience increases the number of perceptual dimensions on which the sound can be classified. Practice listening to specific sounds will influence how we perceive them in the future, and the processes of perceptual learning are the heart of these interactions.

Another salient example of perceptual learning leading to auditory expertise comes from music. Whether listening to the radio, at a concert, or in an environment that has background music, the auditory perception of music is a part of our daily lives. Yet, nonmusicians encode and perceive music differently than do people who have had extensive musical experience. This goes beyond mere music appreciation (some people may prefer heavy metal, but others may feel that it just sounds like noise) and focuses more on the perceptual abilities of musicians (or music aficionados) and nonmusicians. A musician may be able to listen to a piece and pick out individual instruments from among a symphony. Musicians may be able to determine whether an instrument is slightly out of tune or whether the music is being played out of time. They may even be able to identify an individual musician based on the particular musical style. Some gifted musicians may even be able to listen to a piece of music once and replicate it on a particular instrument. Although many novice listeners can appreciate and enjoy music, they perceive music differently based on their previous auditory experience. Recent work in cognitive neuroscience has shown that musicians even use different brain regions when listening to music than do nonmusicians. In all of these cases, perceptual learning increases the number of dimensions on which a sound can be classified and recruits different neural systems.

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See also Auditory Scene Analysis; Perceptual Learning; Speech Perception; Speech Production

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Audition: Disorders

The World Health Organisation (WHO), in its factsheet on deafness and hearing impairment, refers to hearing impairment as "the complete or partial loss of the ability to hear from one or both ears. The level of impairment can be mild, moderate, severe or profound."

The classifications are based on hearing thresholds (see Table 1, next page), most commonly measured using a standard procedure known as pure tone audiometry. In this approach, a measure of the quietest sound an individual can perceive is recorded at a number of different frequencies of sound. Plotting these values creates the audiogram.

WHO estimates from 2001 suggest that if an audiogram were to be recorded for every individual on the planet, approximately 600 million people worldwide would have a hearing loss affecting both ears, and 250 million of these would be of moderate-to-profound severity.

The actual level of disability resulting from a hearing loss is influenced by many factors beyond hearing thresholds. These factors include the amount of distortion in audible sounds, difficulties in processing and filtering auditory information, and the complexity of listening environment exposed to in a hearing impaired person's daily life. In general, a hearing loss of moderate or worse severity in both ears is deemed of particular clinical significance because, to be audible, a significant proportion of speech sounds must be raised beyond normal conversational levels. This has important consequences for the development of speech and language in children, which may be limited unless measures are taken to overcome the loss.

Additional to the level of hearing loss, the affected site or sites along the auditory pathway are used when labeling hearing impairments. Divisions are usually made into conductive (affecting the outer or middle ear), cochlear, retrocochlear (affecting the nerve of hearing), and central (affecting the cognitive processing of sound information).

This entry describes different types of hearing loss as well as some information on the relevant management options available.

Conductive Disorders

A conductive hearing loss occurs when the passage of sound between the outer ear and the cochlea is disrupted.

Obstruction of the Outer Ear Canal

Perhaps the most obvious cause of a conductive hearing loss is the inability of airborne sound waves to reach the tympanic membrane, as a result of occlusion of the ear canal. This may be caused by swelling or discharge resulting from infection (otitis externa), foreign bodies, or cerumen (earwax). Abnormalities during fetal development can result in a complete absence or a progressive narrowing of the ear canal, known as atresia or stenosis, respectively. The latter may occur later in life as a result of exostoses, bony growths commonly associated with extended exposure to cold water, such as repeated sea swimming.

Perforations

A hole, or perforation, in the tympanic membrane reduces the amount of sound energy passed from the ear canal into the middle ear bones. A