Table 1. Summary of common features of today's hearing aids. Portions of this Table were adapted from Mueller and Jorgensen (2020), Hearing Aids for Speech-Language Pathologists. Plural Publishing.

Hearing Aid Feature	**Expected Patient Benefit**
Automatic gain control-input (AGC-I)	The gain that is applied to the input varies based on the input level—more gain for soft sounds than for loud. Allows for packaging a wide range of input levels into the residual dynamic range of the patient.
Automatic gain control-output (AGC-O)	Sets the "ceiling" for the hearing aid output, which is programmed frequency-specific to fall just slightly below the patient's loudness discomfort level (LDL). Limits sounds abruptly with minimal distortions.
Multiple processing channels	Modern hearing aids often have as many as 32 to 48 (or more) frequency channels. This allows for adjustments in gain, output and signal processing to be made in small individual frequency regions, depending on patient specific characteristics.
Multiple memories	A "memory" is fitting parameters that can be programmed totally different than other memories. A patient may have special programs for listening to music or listening in a car. For most situations, the hearing aid automatically selects the most optimum programing for a given listening situation, as determined by the signal classification system. A toggle switch, remote control, or smartphone app allows changes to different programed settings by the patient.
Signal classification	Operates automatically and continually measures the input signal to determine overall level, spectrum of the signal, type of signal

	(speech, noise, music, etc.), and also the azimuth. The algorithm controls features to automatically optimize processing for a given input signal. This classification process is used to control gain and output, and to trigger different types of noise reduction, directional microphones, or beam forming technologies.
Amplitude expansion	Confusing name, as practically, it reduces the amplitude rather than expands it. Expansion compresses low-level signals, typically background noise, to minimize annoyance from amplified microphone noise and low-level environmental sounds. Allows the patient to use the gain necessary to make soft speech audible without negative background noise side effects.
Basic noise reduction	Based on the modulations of the input signal, it reduces overall gain for a given channel when noise is the dominant signal in that channel. Does not improve the SNR directly, as gain is reduced for everything (including speech), but it reduces annoyance and creates more relaxed listening, making daylong listening less fatiguing.
Impulse noise reduction	All incoming signals are analyzed, searching for any spectrum that has a very rapid rise time. When this is detected, the signal is dampened. The effect to the user is a less harsh, smoother signal. Not designed for SNR improvement, but for relaxed listening.
Reverberation reduction	Algorithm examines the timing and repetitions of a given waveform within a few seconds, and when the waveform is repeated (reverberation), the gain of the repetitions is significantly reduced. This causes sharp echoes

	to almost disappear, or at least give them some dullness.
Wind noise reduction	Nearly all hearing aids have two microphone ports. Wind creates a unique turbulence at the ports that is very unique. When this is detected, and the wind noise feature is activated, the hearing aids will automatically reduce gain in the low frequencies. For some products, the hearing aids will determine which side of the head has the least wind noise, and automatically transfer that cleaner signal to the other hearing aid.
Automatic feedback reduction	This feature first detects any *acoustic feedback* or "whistling" and then reduces or eliminates the problem through phase cancellation. This is accomplished by introducing an out-of-phase signal, the same frequency as the feedback. Feature can increase "useable" gain by 10 dB or more.
Basic directional microphone technology	Directional microphone technology reduces the output of the hearing aids for sounds from specific azimuth origins by using two omnidirectional microphones and creating phase delays between the output from them. Sounds (noise) coming from the sides and back can be reduced without changing the output for sounds from the desired listening direction—the look-direction of the patient.
Automatic directional technology	Directional effects are automatically turned on and off as the signal classifier determines, based on the overall input level, and the type of signal (speech vs. noise), if directional processing will be advantageous for the patient.
Adaptive directional technology	Benefit is for isolated noise sources—the noise automatically is located and maximum

	directivity is applied to that azimuth. Can also track a moving noise.
Spatial focus directional technology	Allows for the focus of amplification to be placed to the right or left side, or the back, rather than always toward the front. Signals from other azimuths (presumed to be unwanted) are reduced in output. The hearing aid can be set so that this happens automatically, or it can be manually selected by using a smartphone app.
Bilateral beam forming	Bilateral hearing aids can share full-audio information from the four microphones (two on each side), which allows for creating "beams of focus" for different azimuths. This is referred to as bilateral beam forming. This gives a much narrower beam to the look-direction than can be obtained with traditional directional technology. Most useful when there is single target speaker, or when it's easy to look at the speaker of interest (sitting at a table in noisy restaurant). Can automatic or user-controlled.
Own voice processing	The own-voice feature automatically detects when the hearing aid user is talking (after a minute of training), and then instantaneously reduces gain whenever the person's own voice is detected. As soon as the user's voice stops, gain instantly returns to programmed settings.
Frequency lowering	This technology is accomplished using frequency compression or linear frequency transposition. The algorithm takes the spectral speech energy available at higher frequencies and lowers it to a frequency region where the listener has better thresholds, increasing the likelihood that the speech signal (e.g., such as /s/ or /sh/) will be audible, albeit at a different frequency.

Linked hearing aids	This allows bilateral hearing aids to "talk to each other" and share information through a type of near-field magnetic induction transmission. This linking allows the patient to change a feature on one hearing aid, such as gain, and the other aid will automatically equally change. One hearing aid can control one function and the other hearing aid a different function.
Data logging	The hearing aids keep a record of the daily environments experienced by the patient—such as the overall input level and the SNR for all listening situations—as well as the attributes of the hearing aid function—such as time used, volume control position and the listening program/memory setting. All use data can be read out by the audiologist.
Patient-driven training	When the patient makes adjustments to the hearing aids, the hearing aid "remembers" the pairing of the patient's selection, the input level, and the listening setting (e.g., speech in quiet, speech in noise, noise, music, etc.). Once trained, the hearing aids will automatically go to that setting when that situation is identified.
Audiologist-driven training	For patients who do not immediately accept the desired level of amplification, the audiologist can program the hearing aids to increase gain by a fixed amount (e.g., 1–2 dB/week) over several weeks or months, to provide a gradual acclimatization.
Wireless (Bluetooth) connectivity	Wireless electromagnetic induction allows for bilateral beamformers with full-audio transfer and linked hearing aids. Bluetooth also can be used to connect directly with smartphones,

	computers, personal audio players, and even navigation systems.
Tele-audiology	Through a portal and a smartphone app, audiologists can adjust and re-program hearing aids in the patient's home from their office. This feature also allows for easy messaging with patients, and internet observation of use behavior.
Movement detection	A miniature accelerometer is placed on the chip of the hearing aid, which interfaces with the signal classification system. Depending on if the user is still or moving, the processing of the hearing aid can be programmed to automatically change accordingly.
Geotagging	Through wireless communication with the smartphone, the patient's hearing aids also know where he or she is located geographically, which can assist in selecting a favorite program. With special app, also can be used to find lost hearing aid.
Rechargeable	Charging stations, often a component of the carrying case, eliminate the use of replacement batteries for hearing aid operations. Some products have optional replacement battery use; other products have the battery sealed.