Review article

A review of unilateral hearing loss and academic performance: Is it time to reassess traditional dogmata?

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ABSTRACT

Objective: The aim of this paper was to review traditional approaches to habilitation of unilateral hearing losses as well as new research concerning management of unilateral hearing loss.

Data sources: Literature review/systematic review.

Review methods: A PubMed search was performed for articles pertaining to unilateral hearing loss and academic loss and academic performance. Articles ranged in date from 1986 to 2012. Five resources were reviewed for content to determine the pertinence of the materials to the understanding of the history of diagnosis of unilateral hearing loss, the traditional treatment methods and their advantages and disadvantages, and more recent publications concerning academic outcomes for patients with unilateral hearing loss with and without treatment.

Results: Unilateral hearing loss scan be detrimental to the academic success of children. Effects encompass not only auditory effects such as difficulty hearing in noise, but also self esteem and exhaustion. Although assistive devices were traditionally not offered as options, more recent literature suggests that devices such as BAHA, hearing aids, or FM systems may provide aids in the classroom and that early intervention may provide more favorable outcomes.

Conclusion: Since the 1980s, the approach to management of unilateral hearing losses has evolved. In order to maximize academic potential, treatment options should be discussed and implemented.

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1. Background

Hearing impairment is one of the most prevalent congenital abnormalities in this country with approximately 1–3 per 1000 infants in the United States clinically deaf at birth and an additional 1–6 born with some milder degree of impairment [1]. According to the CDC [2], unilateral, sensorineural hearing loss is the most prevalent form of hearing loss, affecting approximately 3% of school aged children. Despite the advent of newer and more prevalent form of hearing loss, affecting approximately 3% of infants in the United States clinically deaf at birth and an additional 1–3 per 1000 newborns remain at risk of delay of diagnosis throughout infancy and childhood.

Prior to screening, the average age of diagnosis of UHL was 8-years old [4]. Presenting symptoms of UHL can be subtle, such as decreased babbling during the 1st year of life [5] or apparent inattention, which may not be perceived as problematic until the child reaches school age [6]. Lack of toddler/kindergarten screening programs, improper screening techniques, or misinterpretation of the results puts these children with UHL at risk for delayed diagnosis and treatment.

“Unilateral hearing loss (UHL) of any degree can be detrimental to the growth and development of a child.” [7]

Once diagnosed, the traditional dogma in management of UHL is that single-sided hearing is the “minimum requirement” or “adequate” for speech and language development [6]. Children with UHL are capable of performing well in the preschool setting with respect to speech and language development [9].

Once formal schooling begins, these same children can show subtle weaknesses that stem from their impairment. Bess and Tharpe found that students with UHL were frequently labeled as cognitively slow, unintelligent, distracted, aggressive, or misbehaved [7]. Bess and Tharpe evaluated the case histories of 60 children with UHL with particular attention to the academic and social obstacles encountered. This study revealed that 35% had failed at least one grade – most commonly observed early in their academic careers. This percentage was 10-times higher than that of the normally hearing population, in which only 3.5% of the children had ever been retained in a grade. The groups were stratified in several ways to exclude the possibility of confounding, and ultimately it was concluded that single-sided hearing was inadequate for achieving the same success in the classroom as those with binaural hearing [7]. Follow-up revealed that reasoning described for grade-retention was most commonly student “immaturity” or “hyperactivity.”

A subsequent study one year later by Oyler documented similar findings after distributing a set of surveys to teachers; children with hearing impairment were disproportionately described as “underachievers” [11]. The result of this management technique was that the hearing impaired child was removed from the class with which he or she had grown comfortable and joined new students that subsequently recognize and label him or her as “different” [12] and then ostracize the “underachiever” [13].

Reuben and Schwartz [14] showed hearing to be an integral component to proper language development. Students with UHL display difficulty with receptive communication due to background noise and sound localization difficulties. Such difficulties can lead to personal embarrassment and, ultimately, social exclusion.

In a more recent study by Most et al. [15] the examiners used the Hebrew version of the SIFTER (screening instrument for targeting educational risks) to probe the effect of degree of hearing loss on academic performance. Their hypothesis was that degree of hearing loss would correlate to classroom performance and that the more significant the hearing loss, the poorer the academic performance. However, the results showed that children with greater degrees of hearing loss actually scored better academically and in participation than children with milder degrees of loss. It is possible that part of the underlying reason for the disparity may be that children with more significant hearing losses had been provided with intervention in the way of hearing aids and support services at a younger age.

A longitudinal study by Lieu et al. [9] followed 49 children aged 6 to 12years with unilateral hearing loss for 3 years. The subject group included children with both sensorineural hearing loss as well as more permanent conductive hearing losses. Standardized tests for cognition, achievement, and language were evaluated each year. They found that while language and cognition scores improved over time, the average achievement scores did not change. The authors noted that approximately 25% of subjects continued to show academic difficulty after 3 years.

“Single-Sided Hearing is Inadequate for Development.”--Culbertson & Gilbert, Bess & Tharpe

For decades, studies have demonstrated single-sided hearing to be inadequate for proper development [7,10], but the mechanism has been scientifically explored only recently and is unappreciated.
by a large portion of the general public as well as physicians [14].
Carron et al. [17] demonstrated through a questionnaire-based
study that family practitioners, who provide a large portion of
primary pediatric care nationwide, were significantly less knowl-
edgeable about diagnosing and managing congenital hearing loss
compared to pediatricians. Holstrum et al. [8] proposed that the
failure to teach others of the specific difficulties that accompany
UHL is heavily responsible for the slow and substandard evolution
of identifying and managing those with UHL. Even when UHL is
properly identified at an early age and treatments are offered, they
are often imperfect and do not provide sufficient aid to create an
equal opportunity at success [18]. UHL results in more than just an
audiometric loss, and many of the sequelae (described below) are
not compensated for with traditional hearing aid devices, thus
making management difficult.

3.2. Loss of sound source

The most obvious difficulty sustained in living with UHL is the
loss of half of the auditory receivers available to detect sound when
an individual goes from two functional ears to one. If one sustains
any degree of hearing loss, he or she is going to be less able to
perceive sound, especially soft sounds and those that are not
directed toward the functional ear. This is an aspect that can
effectively be addressed with the use of hearing aids, which
amplify the perceived auditory signal [19].

3.3. Sound shadow effects

The “sound shadow” is an effect in which the impaired ear
hinders the ability of the functional ear by casting a dulling effect
upon the functional ear, rendering it less sensitive to auditory
signals [19]. This essentially enhances the audiometric loss that is a
result of impaired sensorineural or conductive components [20].

3.4. Loss of sound localization

Another auditory challenge stems from the lack of a “stereo-
aural” auditory system, when one goes from two functional ears to one.
Those with UHL have been demonstrated in performance studies to
have significant impairment in the ability to localize sound [12,15–
23]. At the minimum, this presents a safety hazard [18]. The
additional effect is a failure to orient within the sound-field to
optimally discriminate a signal from extraneous noise [24].

One method those with UHL employ to overcome this loss of
sound localization is a phenomenon called “learned localization,”
which refers to an increased ability to identify from where a sound
is originating as one adapts over time to UHL [25]. Although the
exact process by which this compensatory mechanism occurs is
unclear, it serves as a plausible explanation for the predominance
of grade failures early in the academic career and a narrowing gap
in success as children age. However, learned localization has not
been shown to fully compensate for UHL and equal the hearing
abilities of the binaural population, thus it should not be mistaken
for being alone adequate for proper development [18].

3.5. Loss of signal from noise discrimination

The decreased ability to discriminate signal from noise is a
multi-factorial problem that is due to a combination of the
audiometric loss, sound shadow effects, and loss of sound
localization [18]. Signal-from-noise discrimination is a practical
measure of hearing function and has emerged as a key determinant
for the efficacy of hearing impairment interventions [26]. Those
who remain unaided or inadequately aided must rely on the ability
to visualize the sound source and focus on a specific tone or quality
of the sound source in order to discriminate signal-from-noise. This
technique is also not as effective as binaural discrimination,
and it demands a significant amount of additional effort and
concentration, particularly if the source of the tone and quality of
voice are similar. This increased energy requirement can affect the
global functioning and well-being of these individuals [21].

3.6. Stress, exhaustion and self-esteem

Results of Bess’ survey-study in 1998 demonstrated that some
children with UHL have significantly decreased self-esteem and
increased level of exhaustion and stress due to effort requirements
to hear [27]. Bess’ study suggests that they could potentially
perform at a higher level and/or they could do so while expending
much less energy. A quick search of the internet reveals multiple
citations regarding “star performers.” In any study population,
approximately 15% may be what are considered “star performers,”
or those who will succeed no matter the resources or circum-
stances. The remaining population is 83% “moderate” performers
and only 2% “poor performers;” this reflects the previously
mentioned studies that the standard for grade retention is
approximately 3.5%. While a subset of UHL patients who are
academically successful will exist, a disproportionately large
student group will risk suffering from the impairment unless
modifying steps are taken, as reflected by the 10-fold increased
level of “poor performers,” such as the 35% grade-retention rate.

3.7. Incomplete bilateral cortical pathway development

According to very recently published works, the developing
brain requires exposure to language models in order to promote
development of higher-order cognitive and psychological path-
ways [28]. Cortical growth and synaptic development, requires
sensory input to stimulate the pathways of development. Those
with a sensory deprivation such as UHL, consequently, experience
cortical reorganization [29].

One example of the impact of this differential development is
the anecdotal phenomenon known as “Right Side Bias.” This refers
to the enhanced negative effects on development that are observed
when UHL occurs on the right side as opposed to the left. To explain
this phenomenon, it has been hypothesized that if someone is not
receiving stimuli through the right ear, the result is a lack of
development in the left-hemisphere, which is usually the site of
the language center [28]. Although behavioral differences have yet
to be proven in studies to be associated with an affected side, there
is an undeniable structural modification that exists in UHL [29].

A similar cortical reorganization process occurs in the setting of
strabismus. In the case of visual sensation deprivation, improper
cortical development can be irrevocable, thus rendering the
patient forever unable to detect visual stimuli that would
otherwise be received by the impaired eye [30]. With early
intervention, this problem is very manageable with a good
prognosis [31]. While Rouger et al. showed that cochlear
implantation can actually allow for cortical reorganization, the
results of delay of treatment remain undefined and concerns for
irreversibility persist. Studies do exist that have shown long-term
use and early intervention to be beneficial [32], and these results
could be explained by such a process of cortical reorganization.

3.8. History of treatment of unilateral hearing loss

Bess and Tharpe’s work in 1986 demonstrated the academic
shortcomings of those with UHL, yet English and Church [33]
showed thirteen years later that still little had been done to
effectively address management of this problem. Their study
determined that over half of those with UHL still required special
education assistance, and nearly a quarter of those with UHL continued to perform at a significantly lower academic level than their peers [33].

3.9. Early intervention evaluations and programs

Despite the goals of the 2000 universal newborn hearing screening, by 2003, only 64% of children who were diagnosed with hearing loss at the newborn screening received intervention by 6 months of age [34]. While some states make services available to all children under the age of 3 years, state and regional funding for, and hence availability of, programs with audiologists, speech/language pathologists and teachers of early intervention varies and is influenced as well by periods of economic prosperity or failure.

3.10. Classroom design and seating

The simplest method employed to help those with hearing impairment succeed academically has been to provide them with preferential seating in the classroom. A position close to the teacher not only allows for better hearing, but it also allows the child to see the teacher and fellow classmates better so that he or she can pick up on visual cues that are often supplemental and very beneficial. While it is important to ensure that steps are taken to provide optimal settings to hear the target signal, limiting extraneous noise is just as important. This includes directing the good ear of the child away from noisy halls, and using classrooms that have permanent walls instead of temporary partitions that are easily traversed by sound waves [35]. In the Bess and Tharpe study [7], a subset of children who met criteria thought to best represent the global population of those with UHL, all those who failed a grade did so despite receiving preferential seating.

Student population size is a modifiable factor in the classroom setting that affects academic success in those with UHL [36]. In classes with fewer students, there is more individual instruction, less distraction, and an increased likelihood of proximity to the instructor. All of these components effectively increase the signal-to-noise ratio—which has been shown to benefit all students and not just those with UHL [37]. These aspects were elucidated in the Student Teacher Achievement Ratio (2001) study, which compared the academic achievements over a 4-year period by those in a “regular” sized class with a mean of 22 students per teacher and those in a “small” sized class with a mean of 15 students per teacher. The study was replicated in multiple states and consistently demonstrated an increased level of achievement by those in the small class, especially in areas where learning impairments or language barriers were prevalent [38]. Small classes are often not considered “cost-effective,” and as fallout from the recent economic decline, student-to-teacher ratios have plateaued [39] and may soon rise at the expense of education.

Another variable is basic acoustic properties of the classroom. This can be influenced by construction materials, room decoration and the physical size of the classroom. The acoustics of 80% of classrooms are not in compliance with American National Standards Institute noise and reverberation standards [40]. Moreover, the prevalence of childhood obesity has doubled in the past share this feature of being either inconvenient or embarrassing, which often leads to non-compliance among children who would rather struggle with their hearing impairment as an alternative to being ridiculed [43].

An alternative to the portable speaker system is to construct speakers into each classroom. This setup was subsequently found to benefit not only those with hearing impairment, but all those sitting around him or her that also enjoyed an enhanced signal-to-noise ratio [44]. However, the cost to install speaker systems into each classroom is greater than providing a single portable speaker to each impaired student. Given that each individual with UHL suffers to a different degree, this arrangement is not able to conform to the specific needs of each child for maximum benefit [44].

The personal ear-level hearing aid that includes FM capabilities has garnered much success in that it is less noticeable than the portable speaker, less expensive than installing speaker systems throughout each classroom, and is fine tuned to each individual who will utilize it [44]. Still, it is often met with the problem of non-compliance due to discomfort and embarrassment [42].

3.12. Amplification devices

The contralateral routing of signal (CROS) amplification device has proven to be of particular benefit in quiet settings. In noisy settings its efficacy is hindered due to amplification of extraneous noise that drowns out the intended signal. As with the traditional ear-level FM device, the appearance of the CROS amplification headset has suffered complaints of discomfort and unpleasant esthetics [45].

The most recent development to assist those with UHL is the bone-anchored hearing amplification (BAHA) device. This device utilizes implantation of a titanium screw into the bone of the impaired ear that becomes osseointegrated over the course of several months. It is connected to an abutment that traverses the skin and connects to a microphone/sound transmitter. The transmitter receives sound vibrations and transduces it to the titanium implant, which then vibrates the temporal bone, conducting sound directly to the inner ear. Having bypassed the external and middle ear compartments, the signal can then be relayed to the functional cochlea to hear – providing binaural hearing to those patients with ipsilateral conductive hearing loss and providing a contralateral microphone to an only-hearing ear in patients with sensorineural hearing loss [46]. The internalized segment of the BAHA device is completely out of sight, bypasses the layer of skin that lies overtop the bone providing less interference and clearer amplification, and its users report decreased discomfort levels compared to the traditional conduction aid [47]. This device has proven superior to the traditional conductive hearing aid in audiologic measures as well as comfort and satisfaction when compared to traditional externally worn devices [48].

Primary drawbacks include the need for essentially irreversible surgical placement of the titanium implant and local skin irritation and scar formation.
3.13. Medical necessity of treatment of UHL

The journey to get insurance coverage for assistive technology for UHL has been long and arduous. “Medical necessity” is a term that appeared in the 1960s from the insurance industry [49]; definitions include: “Services or supplies that are needed for the diagnosis or treatment of your medical condition and meet accepted standards of medical practice (About.com),” “Services or items reasonable and necessary for the diagnosis or treatment of illness or injury or to improve the functioning of a malformed body member [50] (CMS).” While “potentially beneficial but not harmful” used to be sufficient to meet the standards of medical necessity, now a multitude of stringent criteria must be met before insurance agencies will cover interventions. Treatment of UHL is often denied because it does not meet the modern criteria; in summation, since it is not a cure, it is unworthy of financial risk [49].

3.14. Revising the modern approach

This review of the published works over the last three generations of researchers in audiology, otolaryngology and speech pathology is in no way meant to be definitive. In a review of this magnitude, thorough discussion of the scrutiny of each study is impossible to include. However, these researchers, who are pillars in their fields, have published these works often in isolation. Taken comprehensively, they are all pointing toward a need to redesign our practices as clinicians and to be sure to tailor rehabilitative programs for our individual patients.

4. Conclusions

If one accepts that the goals of the provision of medical care to children include the removal of barriers to cognitive, academic and psychosocial development, then logically the same principles should apply to UHL since evidence supports a dependency of complex cognitive development upon optimal hearing, including preferentially restoring adequate bilateral hearing if possible. Therefore, patients with UHL should be properly considered as medically impaired and to benefit from appropriate steps in evaluation and management at an early age.

As has been discussed in detail, the traditional dogma for the minimalist approach to management of the patient with UHL should be re-examined and modified by current evidence. The ideal treatment modality for each individual may vary depending upon the specific needs of the patient. With any treatment modality, early intervention may be the key to maximum benefit, and the student/patient will likely benefit tremendously by evaluation and management at an early age. medially impaired and to benefit from appropriate steps in

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