Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

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Acoustic Reflexes:
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- **Learner Objectives**
  1. **Identify 4 different structures within the acoustic reflex pathways**
  2. **List three distinct acoustic reflex measurements**
  3. **Name 4 evidence-based clinical applications of acoustic reflexes in children and adults**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

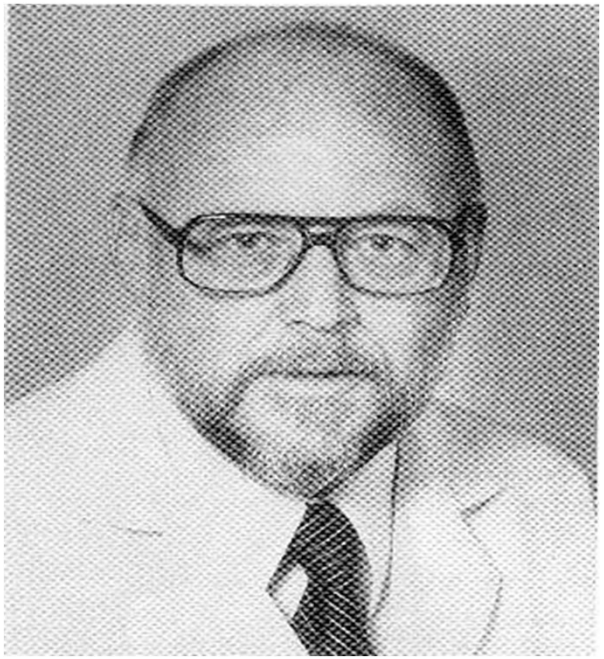
- **0 – 5 minutes:**
  - **Introduction to historical perspective**
- **6 – 15 minutes:**
  - **Acoustic reflex anatomy and pathways**
- **16 – 40 minutes:**
  - **Acoustic reflex measurements in clinical audiology**
- **41 – 55 minutes:**
  - **Clinical applications of acoustic reflexes in children and adults**
- **56 – 60 minutes:**
  - **Questions and Answers**

Acoustic Reflex Measurements:
Historical Perspective

- **Luscher (1929) In Germany observed acoustic reflex**
- **Jepsen (1951) Confirmed stapedius muscle acoustic reflex**
- **Klockhoff (1961) Clinical study of acoustic reflexes**
- **James Jerger (1970) applied electro-acoustic impedance device clinically in U.S.A.**
- **Anderson, Barr & Wedenberg (1970) Early detection of 8th nerve tumors with acoustic reflex**
- **Jerger et al (1974) Sensitivity Prediction by Acoustic Reflex (SPAR)**
- **Keith (1975) Acoustic reflex in neonates**
- **Jerger & Hayes (1976) Crosscheck principle in pediatric audiology**

James Jerger

Classic Impedance Studies in Early 1970s at Methodist Hospital And Baylor College of Medicine in Houston Texas, USA



Clinical Experience With Impedance Audiometry

James Jerger, PhD, Houston

Impedance audiometry was performed as part of the routine clinical examination in a consecutive series of more than 400 patients with various types and degrees of hearing impairment. An electroacoustic bridge (Madsen, ZO 70) was used to carry out the measurement of tympanometry, acoustic impedance, and threshold for the acoustic reflex. Results indicate that, while individual components of the total impedance battery lack diagnostic precision, the overall pattern of results yielded by the complete battery can be of great diagnostic value, especially in the evaluation of young children.

THE development of impedance audiometry during the past decade has added new scope and dimension to clinical audiology. Based on the pioneering efforts of Metz,[1] subsequent workers have refined instrumentation, technique, and interpretation to produce an invaluable tool for differential diagnosis.

The development of contemporary instrumentation for impedance audiometry has, in the main, followed two essentially parallel paths. In the United States, Zwislocki and his colleagues[2-6] developed an electromechanical bridge. In Europe, Thomsen, Terkildsen, Møller, and others,[7-10] pioneered the application of the electroacoustic approach, culminating in the present commercially available electroacoustic bridge.

The present paper reports our clinical experience with the latter instrument based on its routine administration to well over 400 successive patients over a one-year period. Our aim was to assess the efficacy of the electroacoustic approach as a routine clinical procedure and to evaluate its diagnostic value in a typical audiologic case load.

In general we found that the testing procedure was easily mastered, even by audiologically unsophisticated personnel, that valid and meaningful results could be obtained for almost every patient, and that, with certain reservations, the data of impedance audiometry constitute extremely valuable diagnostic information.

Subsequent sections present statistical information when patients are grouped according to age and type of hearing loss, and individual case reports illustrating the diagnostic value of impedance audiometry.

Method

Apparatus.—Impedance audiometry was carried out by means of an electroacoustic impedance bridge (Madsen, type ZO-70) and an associated pure-tone audiometer (Beltone, type 10D). Figure 1 shows a schematic diagram of the principal components of the impedance bridge.

A probe tip containing three tubes is sealed in the external meatus, forming a closed cavity bounded by the inner surface of the probe tip, the walls of the external meatus, and the tympanic membrane. One tube is used to deliver, into this closed cavity, a probe tone generated by a 220-hertz oscillator driving a miniature receiver. The second tube is connected to a miniature probe microphone which monitors the sound pressure level of the 220-Hz probe tone in the closed cavity and delivers the transduced voltage through an amplifier to a bridge circuit and balance meter. The balance meter is nulled by an SPL of exactly 95 dB in the closed cavity. A potentiometer on the output of the 220-Hz oscillator permits variation of the SPL over a range corresponding to a compliance variation (equivalent volume) of 0.2 to 5.0 cc. The third tube is connected to an airpump which permits variation in air pressure in the closed cavity over a range of ±400 mm (water). Air pressure is read on an electromanometer.

Accepted for publication June 19, 1970.

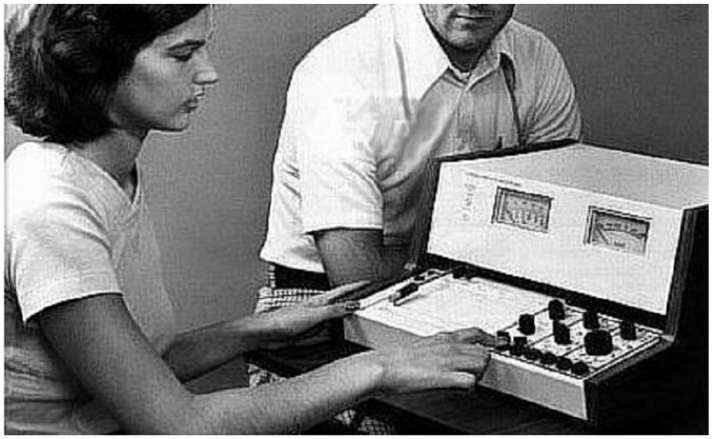
From the Department of Otolaryngology, Baylor College of Medicine, and the Audio-Vestibular Laboratory, the Methodist Hospital, Houston.

Reprint requests to 11922 Taylorcrest, Houston 77024.

554 ears of 336 patients age 10 mos. to 81 years

Two Impedance Devices Used for Clinical Measurements and Research Data Collection

GSI 1720
(1971)



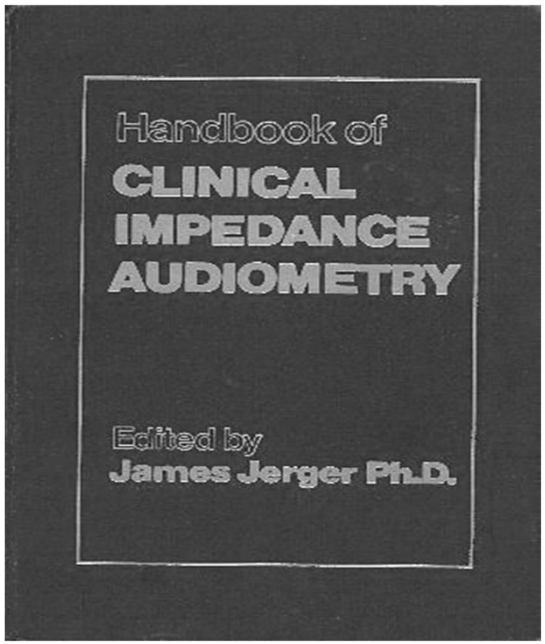
GSI 1723
(1977)

https://peterdanielson.wixsite.com/gs-alumni/nostalgia

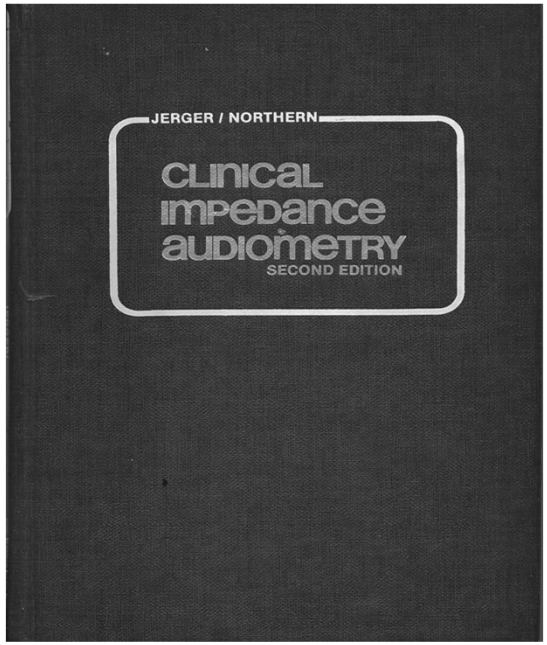
James Jerger Generated Considerable Research Evidence In Support of Admittance Measurements

- Jerger JF (1970). Clinical experience with impedance audiometry. Archives of Otolarynoglogy, 92, 311-324
- Jerger, J., Jerger, S., Mauldin, L. Studies in impedance audiometry. I. Normal and sensori-neural ears. *Arch Otolaryngol* 96:513-523, 1972.
- Jerger, S., Jerger, J., Mauldin, L., Segal, P. Studies in impedance audiometry. II. Children below six years. *Arch Otolaryngol* 99:1-9, 1974.
- Jerger, J., Anthony, L., Jerger, S., Mauldin, L. Studies in impedance audiometry. III. Middle ear disorders. *Arch Otolaryngol* 99:165-171, 1974.

James Jerger
First Books on “Impedance Audiometry

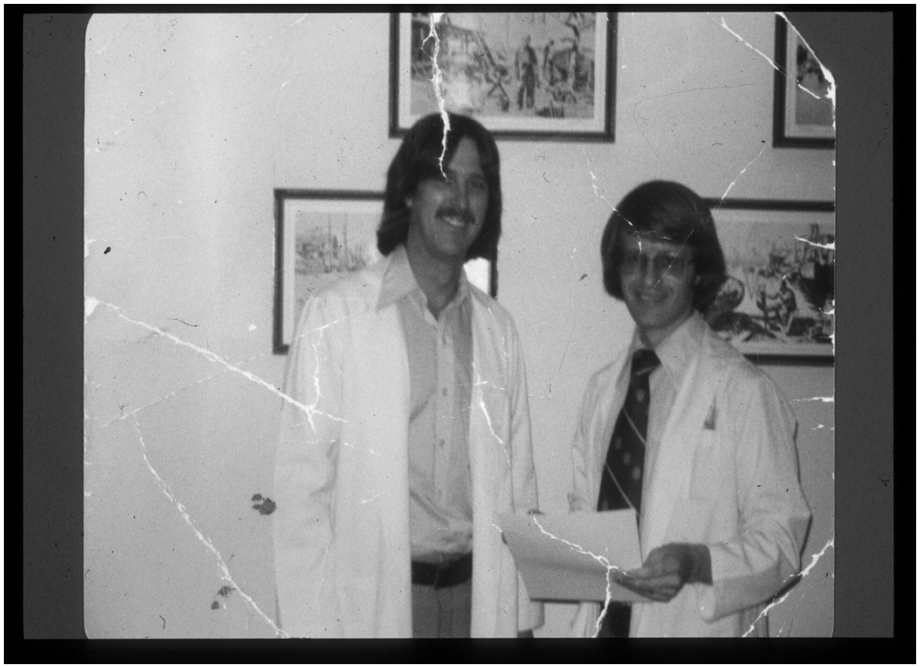


1975



1980

Acoustic Immittance Measurement:
My First Clinical Activity at Baylor College of Medicine
(Houston Texas)



With Larry Mauldin (circa 1975)

Early Publications on Impedance/Immittance Measures

- Hall, JW III and Jerger JF. Acoustic reflexes in spastic dysphonia. *Archives of Otolaryngol 102*: 411-415,1976 [Pub #1]
- Hall JW III. Predicting hearing level from the acoustic reflex: A comparison of three methods. Archives of Otolaryngol 104: 601-605, 1978
- Jerger JF, Jerger S and Hall JW III. A new acoustic reflex pattern. Archives of Otolaryngol 105: 24-28, 1979
- Hall JW III. The effect of age and sex on static compliance. Archives of Otolaryngol 105: 153-156, 1979
- Hall JW III and Weaver T. Impedance audiometry in a young population: The effects of age, sex and minor tympanogram abnormality. J Otolaryngology (Toronto) 8: 210-222, 1979

Acoustic Reflex Amplitude in Auditory Dysfunction
Dissertation: James W. Hall III, 1979

ACOUSTIC REFLEX AMPLITUDE IN
AUDITORY DYSFUNCTION

A Dissertation Submitted to the Faculty of
The Graduate School
Baylor College of Medicine

In Partial Fulfillment of the
Requirements for the Degree
of

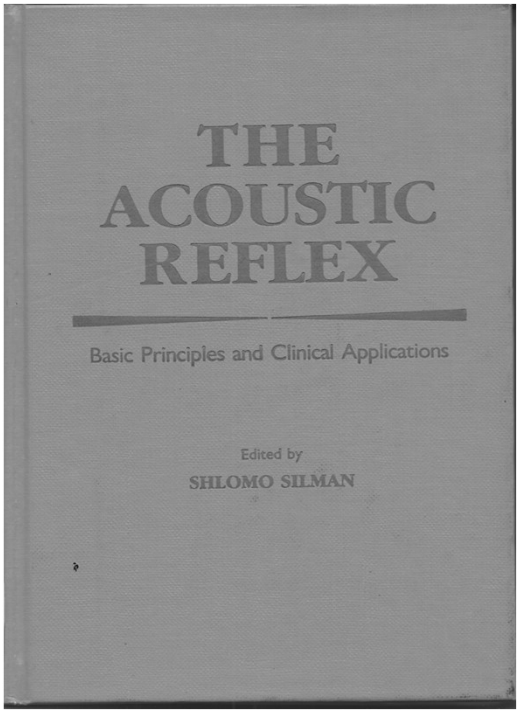
Doctor of Philosophy

by

JAMES W. HALL III

Houston, Texas
August 3, 1979

An Old but Good Source of Information on the Acoustic Reflex (Editor: Shlomo Silman, Academic Press 1984)



Chapter 1: Neurophysiologal Basis
(Aage Moller)
Chapter 4: Evaluation of Response Time of Acoustic Immittance Instruments
(David Lilly)
Chapter 6: Prediction of hearing loss
(Silman et al)
Chapter 7: Magnitude and Growth
(Silman)
Chapter 8: Acoustic Reflex Latency
(Bosatra, Russolo & Silverman)
Chapter 13: Effect of Drugs and Disease
(Mangham)

Decrease in Proportion of Audiologists Who Record Acoustic Reflexes … Beginning in 1990s

Martin FN et al (1998). Seventh survey of audiometric practices in the United States. *JAAA, 9,* 95-104

Journal of the American Academy of Audiology/Vol

ear. A smaller percentage (32%) mask when there is a specified difference between the speech thresholds of the two ears. This difference, as reported by the respondents using this method, ranges from 5 to 70 dB. It appeared more common to use a set amount of masking when needed for word-recognition testing. Standard amounts were reported as 50 to 75 dB HL. Many respondents also base their masking level for word-recognition testing on the stimulus level

Nowadays Fewer Audiologists Record Acoustic Reflexes in Clinical Practice

- Emanuel et al (2012). Survey of audiological immittance practices. *AJA, 21,* 60-85
  - Survey responses from 156 audiologists (2008 + 2009)
  - Decrease in contralateral acoustic reflex testing over time
  - Patient discomfort is reported but without evidence
- Emanuel DC et al (2011). Survey of diagnosis and management of auditory processing disorder. AJA, 20, 48-60
  - Survey responses from 192 audiologists who perform APD assessments
  - >90% of audiologists evaluate APD in children
  - 69% of audiologists perform acoustic reflex threshold measurements vs. 97% who perform tympanometry

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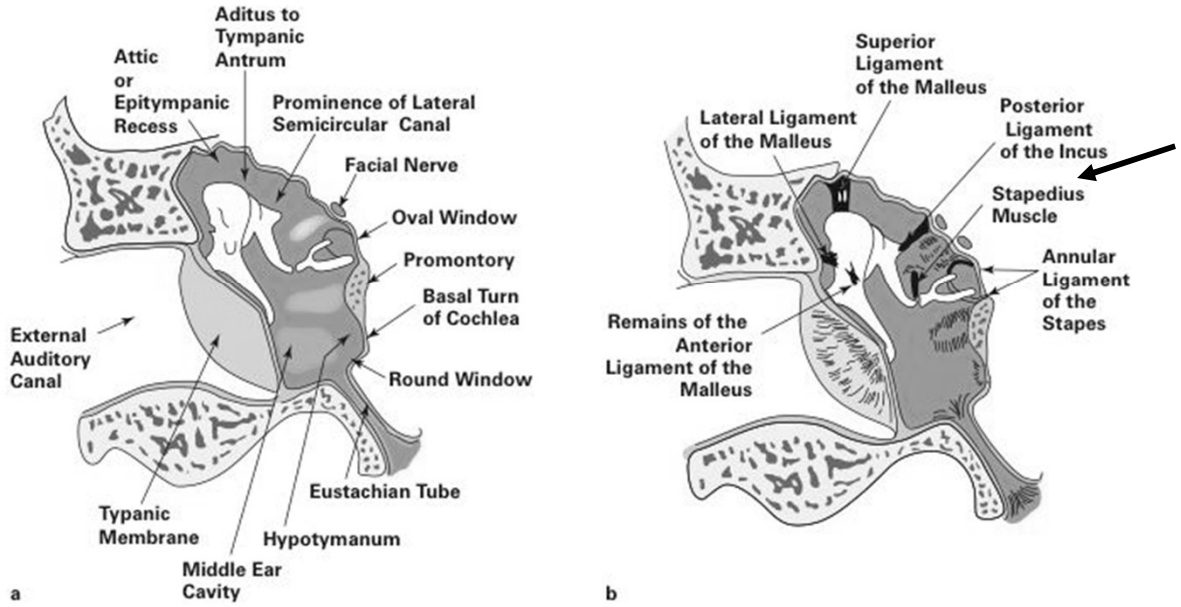
Acoustic Reflex Measurements

Middle Ear Muscles (Stapedius and Tensor Tympani)

- **Stapedius muscle**
  - **Small striated muscle (smallest in the body)**
  - **Located in a canal posterior to tympanic cavity**
  - **Attached at one end to the canal and the other to the neck of the stapes**
  - **Innervated by a branch of the 7th (facial) cranial nerve**
  - **Consensual reflex (unilateral stimulus bilateral response)**
  - **Stimulated in various ways including**
    - **Acoustic reflex by sounds of about 85 dB HL**
    - **Gentle tactile stimulation of outer ear**
    - **Electrical stimulation of ear canal wall**
    - **Voluntary contraction (can you wiggle your ears?)**

Middle Ear Muscles:
Stapedius Muscle

(From Hall JW III (2014). *Introduction to Audiology Today*. Boston: Pearson)



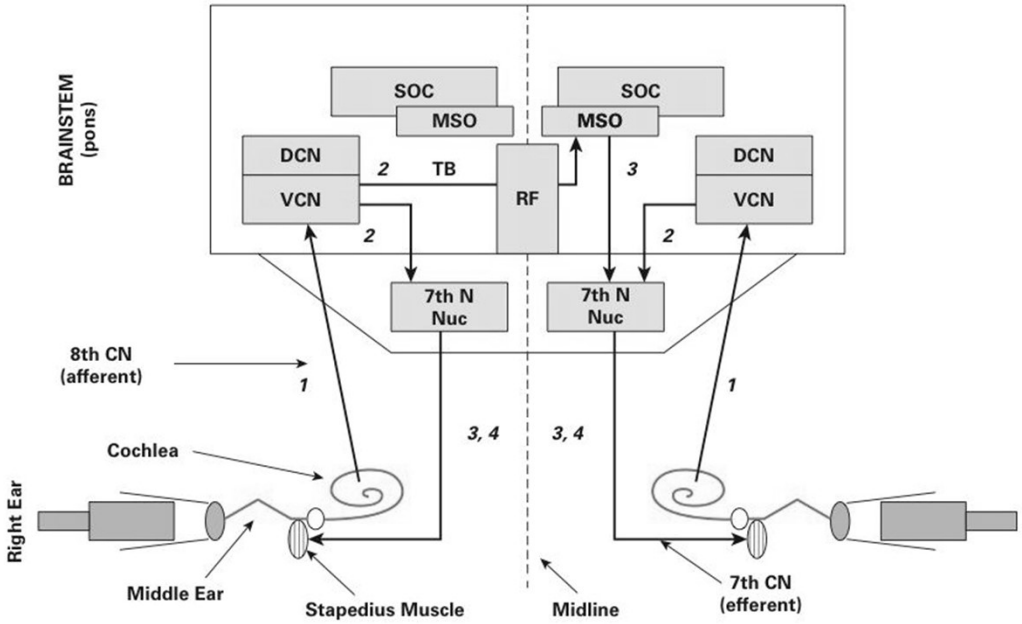
Acoustic Reflex Measurements

Middle Ear Muscles (Stapedius and Tensor Tympani)

- **Tensor tympani muscle**
  - **Striated muscle**
  - **Located in a small canal above the auditory canal**
  - **Attached at one end to the walls of the canal and the other to the manubrium of the malleus**
  - **Innervated by mandibular branch of the 5th (trigeminal) cranial nerve**
  - **Contracts as part of general startle response**
  - **Response is usually transient and not repeatable**
  - **May play a role in tinnitus, e.g., Wescott et al (2013). Tonic tensor tympani syndrome in tinnitius and hyperacusis patients: A multi-clinic prevalence study Noise & Health, 15, 117-128 [Melbourne Australia]**

Acoustic Stapedial Reflex Pathways According to Erick Borg

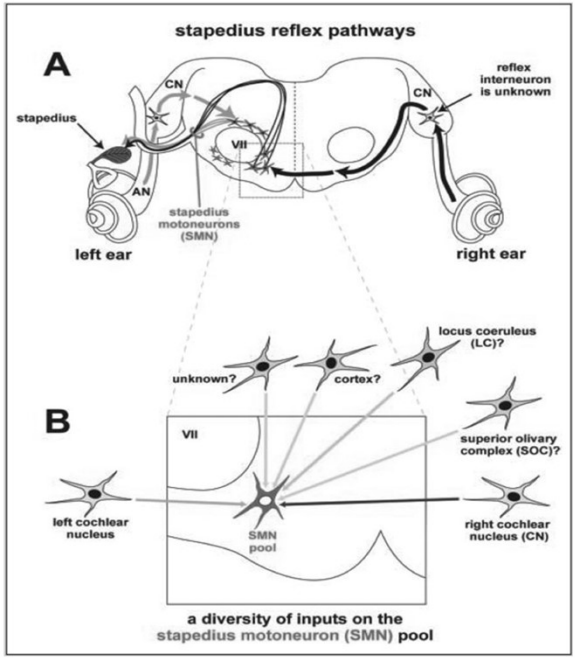
(From Hall JW III (2014). *Introduction to Audiology Today*. Boston: Pearson)



Acoustic Reflex Pathways Revisited

(*Mukerji, Windsor & Lee. Auditory brainstem circuits that mediate middle ear muscle reflexes. Trends in Amplification, 14, 2010)*

Mukerji, Windsor & Lee. Auditory brainstem circuits that mediate middle ear muscle reflexes. Trends in Amplification, 14, 2010. ***[Norway]***



Stapedial reflex pathways

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Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Clinical Instrumentation

- Ear canal volume
- Static compliance
- Tympanometry
  - 220 vs. 1000 Hz probe tones for
  - adults vs. neonates
  - Multiple admittance components
  - Toynbee and Valsalva procedures
  - Fistula test
- Acoustic reflexes
  - Ipsi - and contralateral
  - Right and left ear

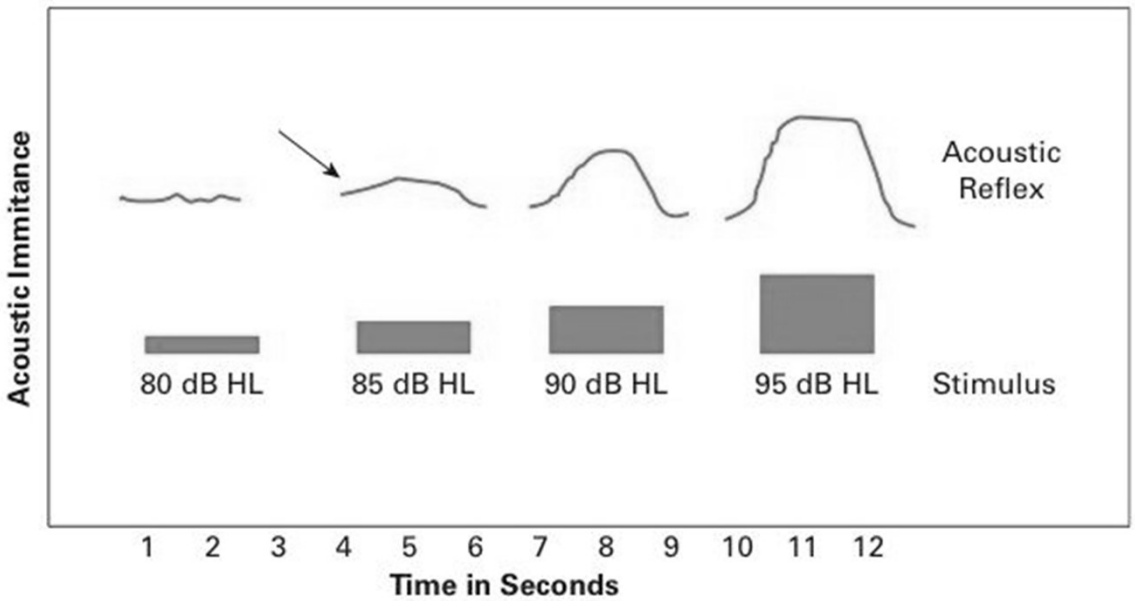
Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Four Clinically Feasible Measurements

- **Acoustic reflex threshold (ART)**
- **Acoustic reflex decay**
- **Acoustic reflex amplitude growth**
- **Acoustic reflex latency**

Acoustic Reflex Measurements

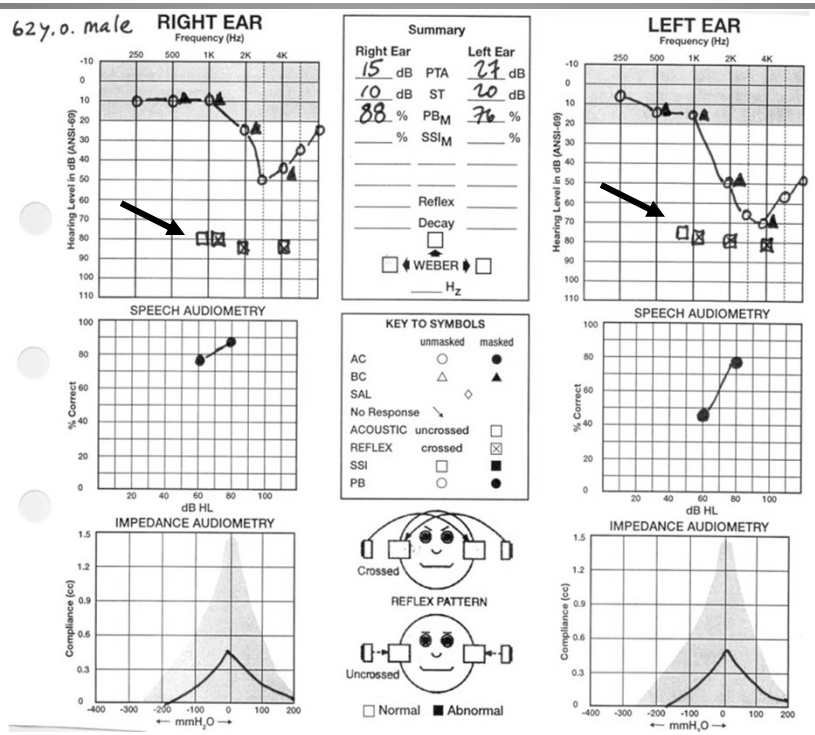
Acoustic Reflex Threshold

(From Hall JW III. *Introduction to Audiology Today*. Boston: Pearson, 2014)



TympStar Pro quantifies minimum verified admittance change., e.g., 0.02 mmho)

Plotting Acoustic Reflex Threshold Results on an Separate Ear (Jerger) Audiogram Form



FaceBook Chatter About How Often Acoustic Reflexes are Typically Recorded in Normal Hearers

Krystyna N. Graham
December 12 at 1:55pm

Wondered how much weight you all give to absent acoustic reflexes when you'd expect them all to be present and robust (i.e. Normal hearing or very mild SNHL)? Do you refer to ENT? Ask that the patient return in a certain amount of time to monitor it? Or do you simply record it as "their normal" and make a note of changes in the future? Are you more concerned if ipsi aren't present as opposed to contra...or if all are absent instead of just 4kHz?....Orrrr do you not even perform reflex testing at all 🤔👀

1 14 Comments

Like Comment

Christopher Scot Frink If they have no other mitigating symptoms, I don't worry about it. Reflexes are simply a test of objective tolerance for loud sounds. Taken by themselves, they aren't of great value. In combination with other diagnostic tests, they can support or refute a diagnosis. If there's no pure tone asymmetry, no dizziness, no tinnitus, etc. I simply record and monitor.
Like · Reply · 14 · December 12 at 2:03pm

Jennifer Harris Torres I tend to agree. There is a decent % of people who do not have reflexes.
Like · Reply · 2 · December 12 at 10:59pm

Christopher Scot Frink We have a staff member who has normal hearing, no reflexes, but on top of this, she can "fake" a reflex. You may think this impossible, but really when we run them, she can say "OK, this time there won't be any reflexes" (her normal status) and then we run them again and she can make it happen. Bizarre.
Like · Reply · 1 · December 12 at 11:24pm

Acoustic Reflex Thresholds in Normal Hearers with Pure Tone Thresholds < 25 dB HL

(Hunter, 2013)

Study	Acoustic Reflex Thresholds (Contralateral Condition)* *10th to 90th %ile*
500 Hz	75 to 95 dB HL
1000 Hz	75 to 95 dB HL
2000 Hz	75 to 95 dB HL

Note:

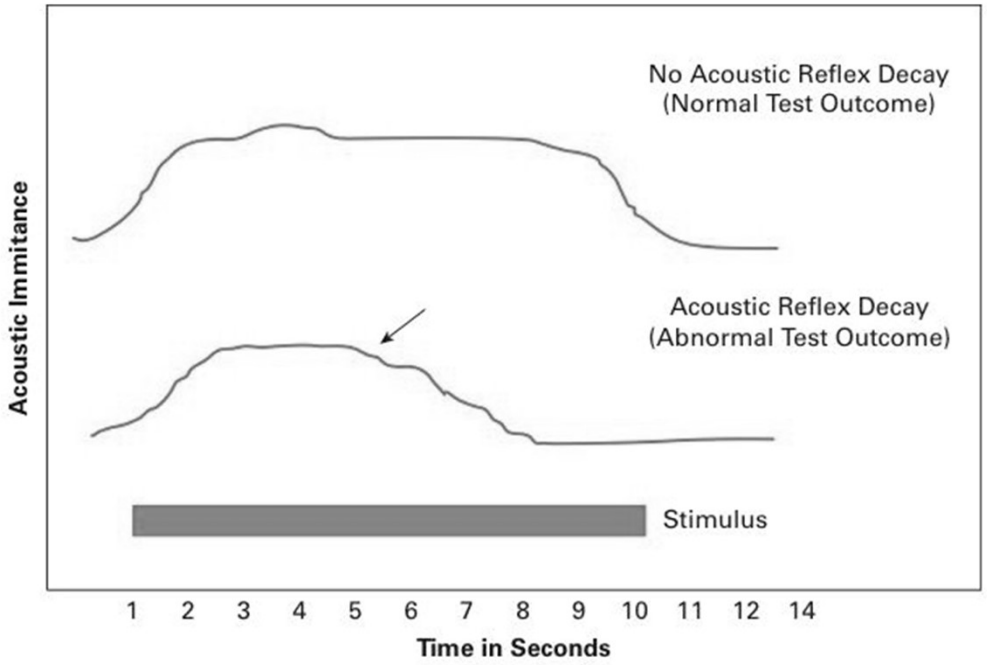
- **Acoustic reflexes are recorded in > 95% of normal hearers.**
- **Data for a 4000 Hz signal are not included and not recommended clinically due to high percentage of normal hearers with absent acoustic reflexes.**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Clinically Feasible Measurements

- **Acoustic reflex threshold (ART)**
- **Acoustic reflex amplitude**
- **Acoustic reflex decay**
  - **Anderson H, Barr B & Wedenberg E (1970). Early diagosis of VIIIth nerve tumours by acoustic reflex tests. *Acta Oto-laryngologica, 69*, 232-237**
  - **Olsen WO, Noffsinger D & Kurdziel S (1975). Acoustic reflex and reflex decay: Occurrence in patients with cochlear and eighth nerve lesions. *Archives of Otolarynoglogy-HNS, 101,* 622-625**
- **Acoustic reflex latency**

Acoustic Reflex Latency: Acoustic Reflex Threshold + 10 SL

(From Hall JW III. *Introduction to Audiology Today*. Boston: Pearson, 2014)



Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Clinically Feasible Measurements

- **Acoustic reflex threshold (ART)**
- **Acoustic reflex decay**
- **Acoustic reflex amplitude**
- **Acoustic reflex latency**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

Acoustic Reflex Amplitude

ACOUSTIC REFLEX AMPLITUDE IN
AUDITORY DYSFUNCTION

A Dissertation Submitted to the Faculty of
The Graduate School
Baylor College of Medicine

In Partial Fulfillment of the
Requirements for the Degree
of

Doctor of Philosophy

by

JAMES W. HALL III

Houston, Texas
August 3, 1979

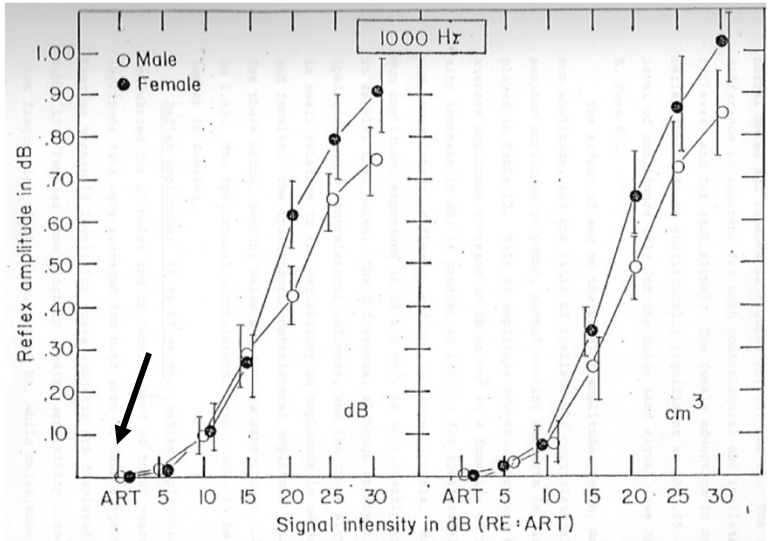


Figure 20. Ipsilateral reflex amplitude for 1000 Hz signal in 10 young, normal hearing males and 10 young, normal hearing females. Data are plotted in dB (SPL in 2 cm^3 cavity) on left ordinate, and in cm^3 on right ordinate. Signal intensity is in dB RE: Acoustic Reflex Threshold (ART). Data are averaged for both ears. Average static compliance(cm^3): males, .79, females, .80; average ear canal volume(cm3): males, 1.16, females, 1.23. Brackets (I)

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

Acoustic Reflex Amplitude

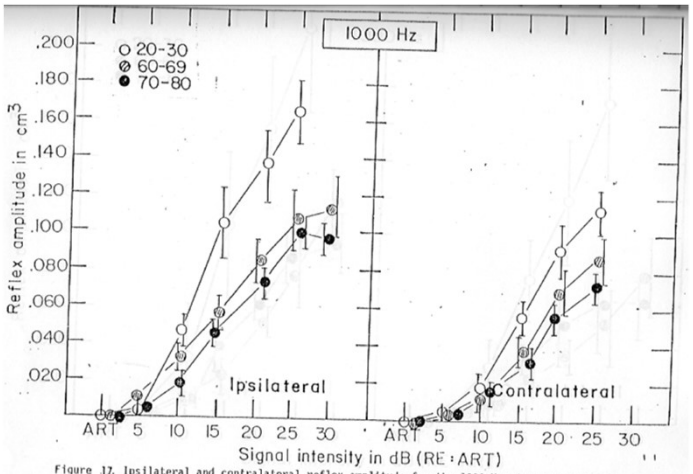


Figure 17. Ipsilateral and contralateral reflex amplitude for the 1000 Hz signal in three age groups of 16 subjects each (20 to 30 years, mean age 27; 60 to 69 years, mean age 66; 70 to 80 year mean age 73). Data are plotted in cm^3. Signal intensity is in dB RE: Acoustic Reflex Thresh (ART). Data are averaged for both ears. Average static compliance and ear canal volume for each age group were described in legend of Figure 16. Brackets (I) indicate standard error of

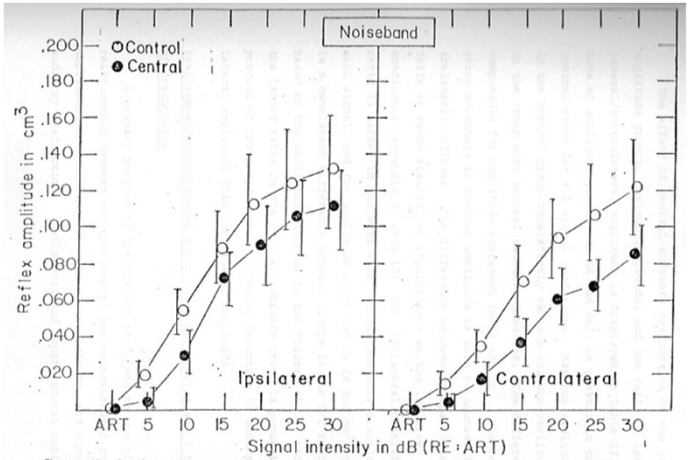


Figure 47. Ipsilateral and contralateral reflex amplitude for the noise band signal (500-1500Hz) in 10 subjects with central auditory dysfunction as indicated by speech audiometry and 10 control subjects. Amplitude data are plotted in cm^3. Signal intensity is in dB RE: Acoustic Reflex Threshold (ART). Data are averaged for both ears. Age, static compliance and ear canal volume for both groups are described in Figure 44. Brackets (I) indicate standard error of the mean.

Published Articles on Acoustic Reflex Amplitude (Based on PhD Dissertation)

- **Hall JW III. Acoustic reflex amplitude: I. Effect of age and sex. *Audiology (Basel) 21:* 294-309, 1982**
- **Hall JW III. Acoustic reflex amplitude: II. Effect of age-related auditory dysfunction. *Audiology (Basel) 21:* 386-399, 1982**
- **Hall JW III. Quantification of the relationship between crossed and uncrossed acoustic reflex amplitude. *Ear and Hearing 3:* 296-300, 1982**
- **For further review of acoustic reflex amplitude see:**
  - **Shlomo S (1984). Magnitude and growth of the acoustic reflex. *The Acoustic Reflex: Basic Principles and Clinical Applications*. New York: Academic Press**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Clinically Feasible Measurements

- **Acoustic reflex threshold (ART)**
- **Acoustic reflex decay**
- **Acoustic reflex amplitude**
- **Acoustic reflex latency**

Norris TW, Stelmachowitz P, Bowling G & Taylor D (1974). Latency measures of the acoustic reflex. *Audiology, 13,* 464-469

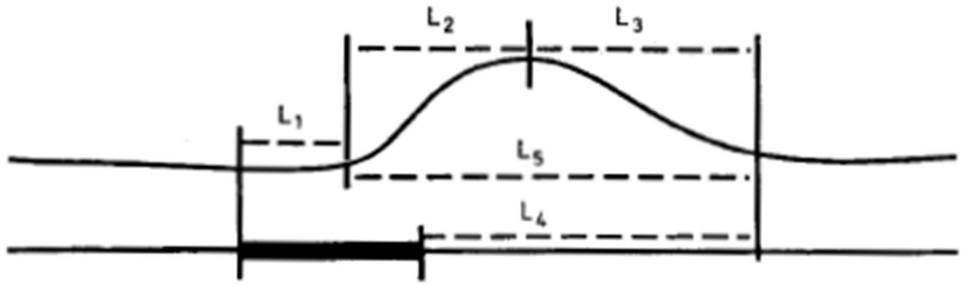


Fig. 1. Measurement technique.

	L_1	L_2	L_3	L_4	L_5
Normal group	129.1	245.2	282.2	395.2	527.4
Sensorineural group	136.5	294.3	595.2	753.9	889.6

Acoustic Reflex Latency: Distortion in Measurements Due to Time Constants of Early Analog Devices

GSI 1723

Total of 5 time constants ~ 400 ms for GSI 1720 (Popelka, 1981)

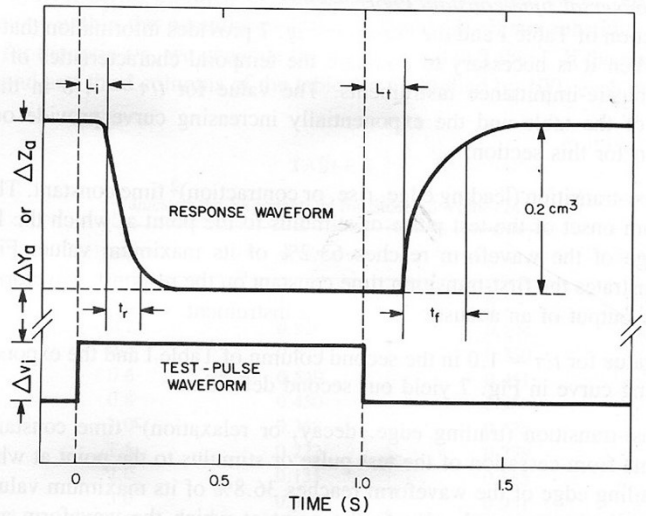


Fig. 8 Analog electrical-output waveform (upper curve) from a commercial acoustic-immittance instrument (Grason Stadler 1723) when procedure suggested by Popelka and Dubno (1978) was used to measure its temporal characteristics. Initial latency L_i, risetime t_r, terminal latency L_t, and falltime t_f are identified. (After ANSI, 1982; Popelka, 1979.)

Acoustic Reflex Latency: Distortion in Measurements Due to Time Constants of Early Analog Devices

Lilly D (1984) Acoustic reflex latency: State of the art. In Silman S (ed). *The Acoustic Reflex: Basic Principles and Clinical Applications*. New York: Academic Press.

”In general the time constant is a measure of duration. More specifically, it is a measure of how rapidly a quantity such as voltage, current, displacement, sound pressure, or volume velocity changes in a circuit in response to a rapidly changing input signal.” (p. 110)

“The temporal characteristics of the instrumentation can have a profound effect upon … [acoustic reflex latency] (p. 130)

Acoustic Reflex Latency: Distortion in Measurements Due to Time Constants of Early Analog Devices

Bosatra et al (1984). Acoustic reflex latency: State of the art. In Silman S (ed). *The Acoustic Reflex: Basic Principles and Clinical Applications*. New York: Academic Press.

"It must be added, however, that to adequately study the temporal characteristics of the acoustic reflex (e.g., latency, rise, and decay time) using the impedance method, the output of the impedance bridge must be fed into a dual-trace storage oscilloscope. The pen-recording method is not precise enough, mostly because of the inertia of the pen recording." (p. 302)

Factors and Parameters Possibly Influencing Acoustic Reflex Latency Measurements (From Bosatra et al, 1984)

- Stimulus Parameters
- Subject Factors
- Diseases and Disorders
- Drugs and Medications

Factors and Parameters Possibly Influencing Acoustic Reflex Latency Measurements

(Data reported by Bosatra et al, 1984)

- **Stimulus parameters**
  - **Laterality Test Condition: Shorter latency for ipsilateral than contralateral stimulation**
  - **Rise time: Faster rise time results in shorter latency**
  - **Intensity: Higher intensity results in shorter latency**
  - **Frequency**
    - ✓ **ARL differences for 500 Hz, 1000 Hz, 2000 Hz, and BBN**
    - ✓ **No data for other frequencies**
  - **Duration: Probably not a factor**

Factors and Parameters Possibly Influencing Acoustic Reflex Latency Measurements *(From Bosatra et al, 1984)*

- **Subject factors**
  - **Age**
    - ✓ **Infants and young children: No data**
    - ✓ **Advancing: Latency increases with age > 60 years**
  - **Gender: No data**
  - **Body temperature: No data**
  - **State of arousal (e.g., sleep): No data**
  - **Test ear (right versus left): No data**
  - **Intra-subject variability: Small (< 10 ms) or none**

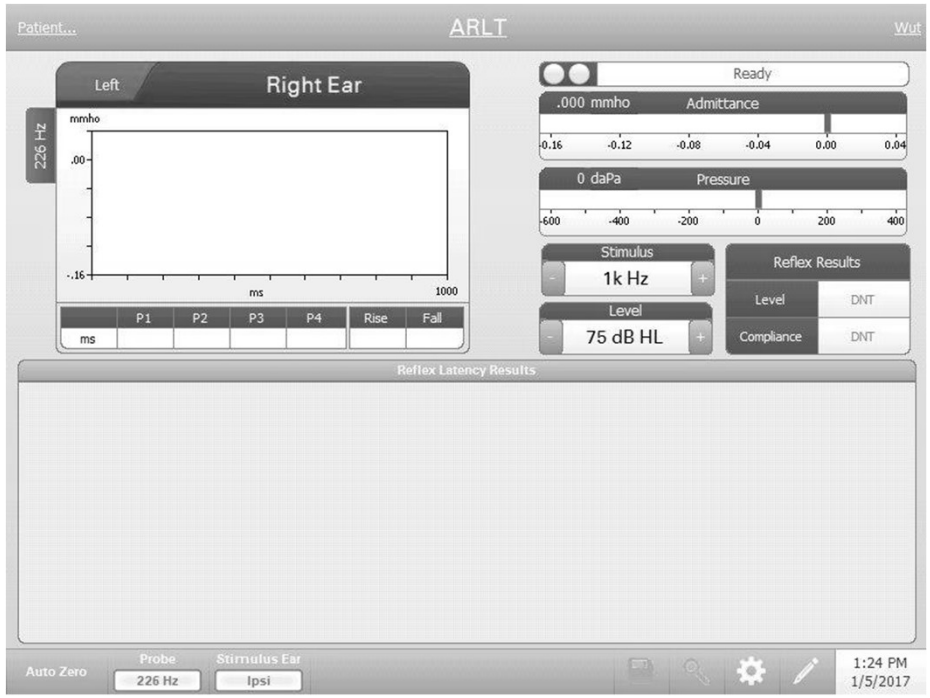
Factors and Parameters Possibly Influencing Acoustic Reflex Latency Measurements *(From Bosatra et al, 1984)*

- **Diseases and disorders: Cochlear and Retrocochlear**
  - **Cochlear pathology:**
    - ✓ **Meniere's disease: No consistent effect when acoustic reflexes were present**
    - ✓ **Sudden hearing loss: Abnormally long ARL when acoustic reflexes are present**
  - **Retrocochlear pathology:**
    - ✓ **Abnormally long ARL when acoustic reflexes are present**
    - ✓ **Significant inter-aural latency difference in unilateral pathology**

Factors and Parameters Possibly Influencing Acoustic Reflex Latency Measurements *(From Bosatra et al, 1984)*

- **Diseases and disorders: Central auditory nervous system**
  - **Brainstem**
    - ✓ **Vascular: Normal ARL when acoustic reflexes are elevated**
    - ✓ **Multiple sclerosis: Normal ARL**
    - ✓ **Intra-axial tumor: Abnormally long ARL**
  - **Cortical:**
    - ✓ **Normal ARL**
- **Drugs**
  - **Sedation and anesthesia: No data**
  - **Pentobartitol: Abnormally long ARL when present**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

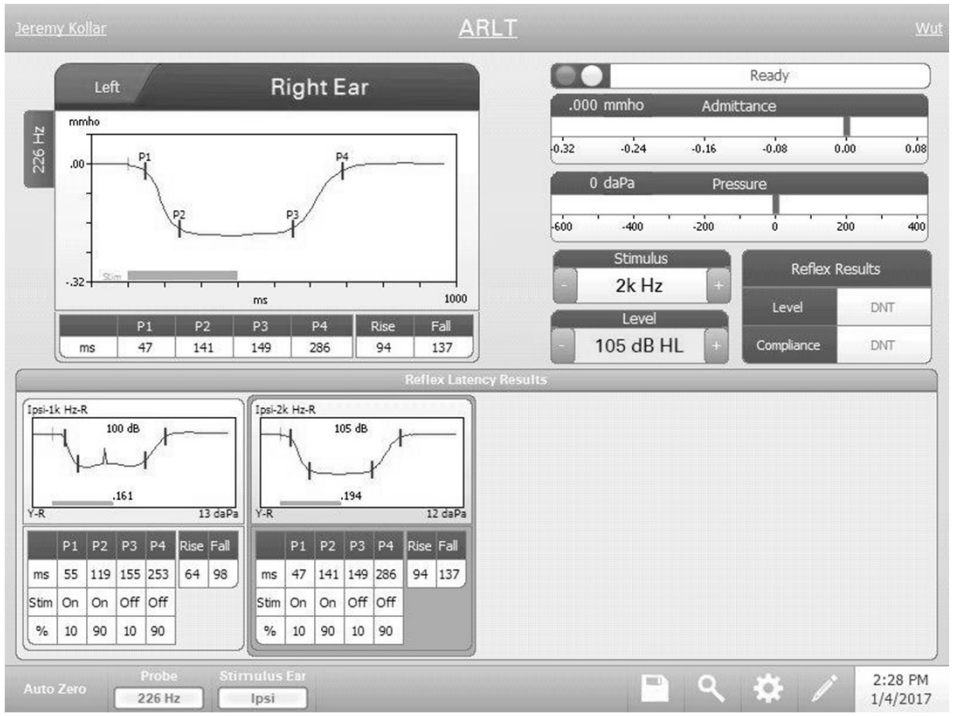


Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

	P1	P2	P3	P4
ms	47	141	149	286
Stim	On	On	Off	Off
%	10	90	10	90

	Rise	Fall
ms	94	137
From	P2 - P1	P4 - P3

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized



Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

I predict a bright future for the Acoustic Reflex Latency Test (ARLT)

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

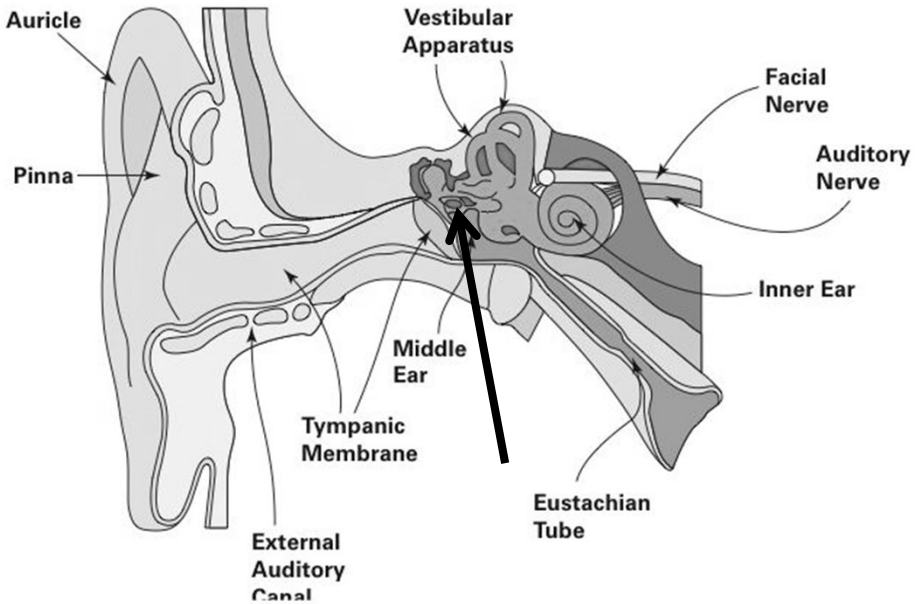
- **0 – 5 minutes:**
  - **Introduction to historical perspective**
- **6 – 15 minutes:**
  - **Acoustic reflex anatomy and pathways**
- **16 – 40 minutes:**
  - **Acoustic reflex measurements in clinical audiology**
- **41 – 55 minutes:**
  - **Clinical applications of acoustic reflexes in children and adults**
- **56 – 60 minutes:**
  - **Questions and Answers**

Year 2007 Joint Committee on Infant Hearing (JCIH): Protocol for Evaluation for Hearing Loss In Infants from Birth to 6 months

- Child and family history
- Evaluation of risk factors for congenital hearing loss
- Parental report of infant's responses to sound
- Clinical observation of infant's auditory behavior
- Audiological assessment
  - Auditory brainstem response (ABR)
  - Otoacoustic emissions (distortion product or transient OAEs)
  - Tympanometry with 1000 Hz probe tone
  - Supplemental procedures, e.g.,
    - Electrocochleography (ECochG)
    - Auditory steady state response (ASSR)
    - Acoustic reflex measurement (for 1000 Hz probe tone)

Acoustic Reflex Measurement in the Detection of Subtle Middle Ear Disorders (≤ 10 dB ABG)

(From Hall JW III. *Introduction to Audiology Today*. Boston: Pearson, 2014)



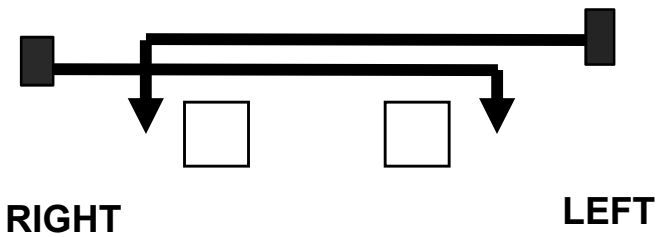
Plotting the Pattern of Results of Acoustic Reflex Measurements in Four Conditions *(Describe Reflexes by Stimulus Ear)*

Abnormal Acoustic Reflex

Acoustic reflex patterns ("faces")

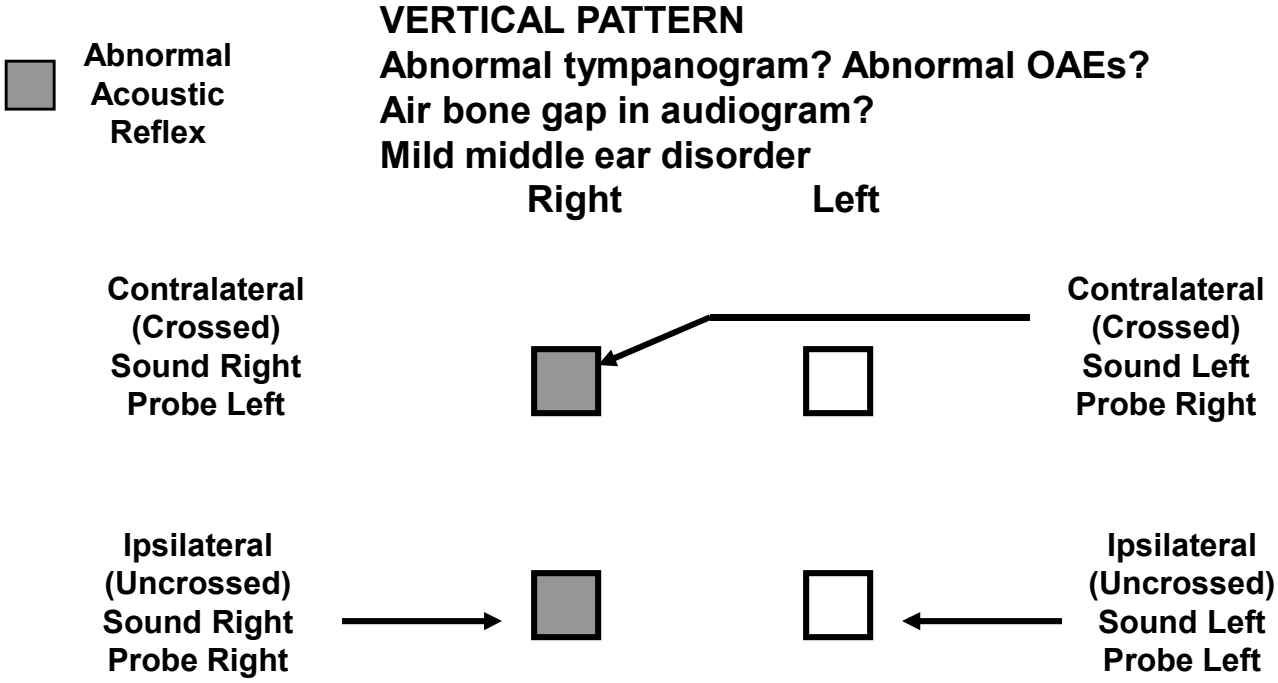
- Conductive/efferent pattern
- Sensory pattern
- Neural pattern
- Brainstem pattern

Crossed (contralateral)
Sound in one ear and
probe in opposite ear

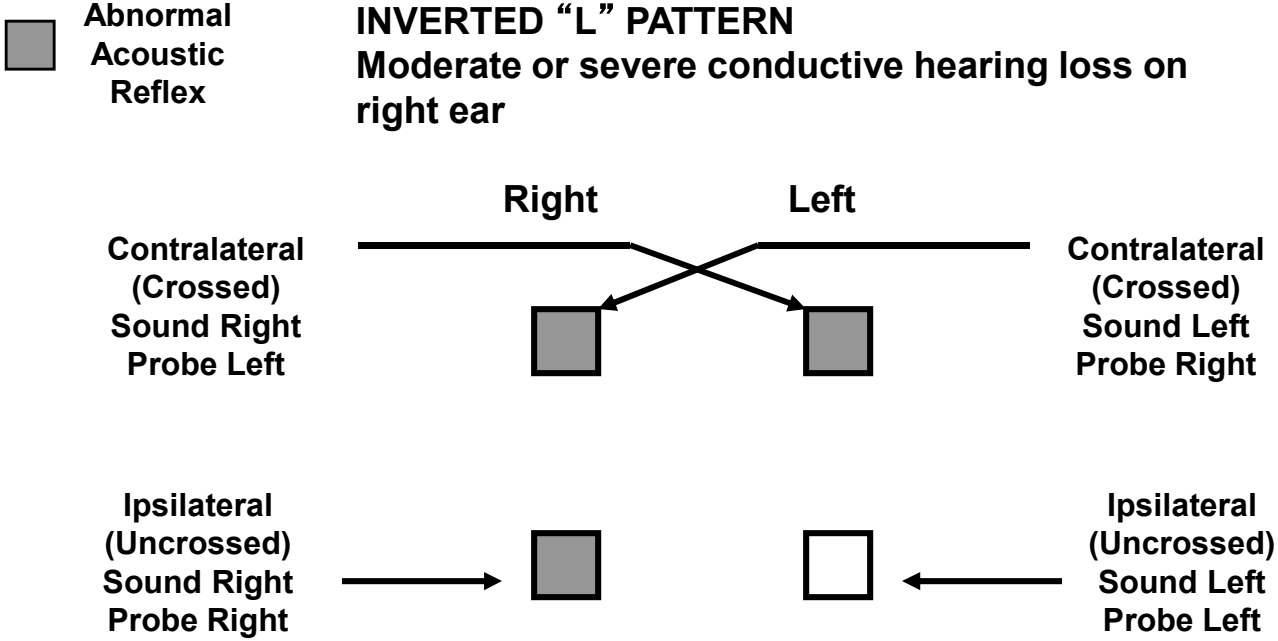


Uncrossed (ipsilateral)
Probe and sound
in same ear

Plotting the Results of Acoustic Reflex Measurements



Plotting the Results of Acoustic Reflex Measurements

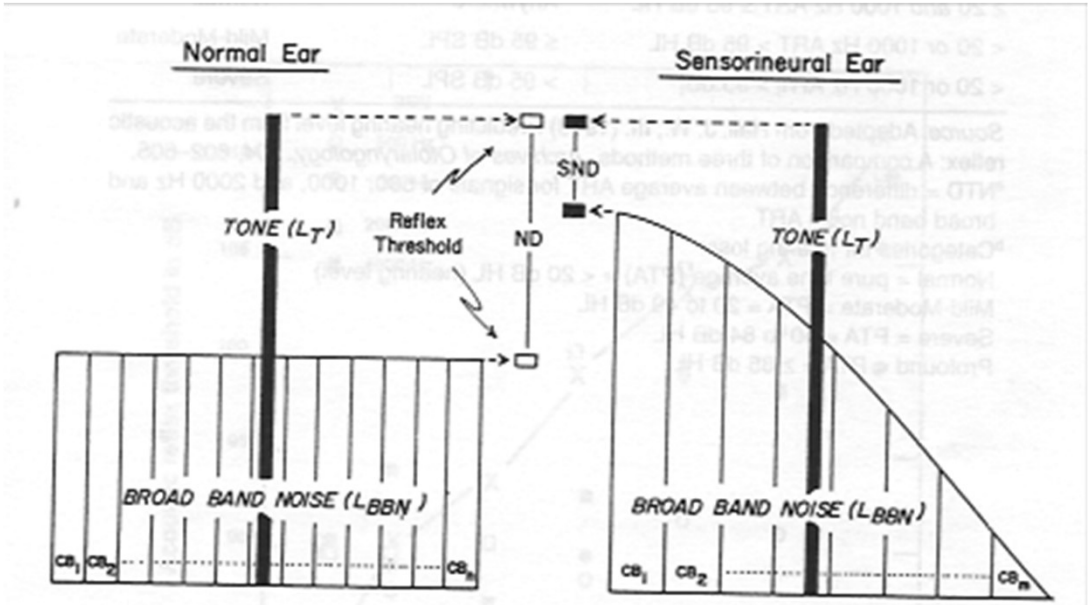


INVERTED "L" PATTERN
Moderate or severe conductive hearing loss on right ear

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Objective differentiation of normal hearing sensitivity versus sensory hearing loss**
  - **Detection of 8th nerve dysfunction**
  - **Detection of 7th nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**
  - **Identification of false or exaggerated hearing loss**

Jerger J, Burney P, Mauldin L & Crump B (1974).
Predicting hearing loss from the acoustic reflex. *JSHD, 39,* 11-22



From the original paper on Sensitivity Prediction by Acoustic Reflex (SPAR) by Jerger et al., 1974.

SPAR Criteria

Jerger J, Burney P, Mauldin L & Crump B (1974).
Predicting hearing loss from the acoustic reflex. *JSHD, 39,* 11-22

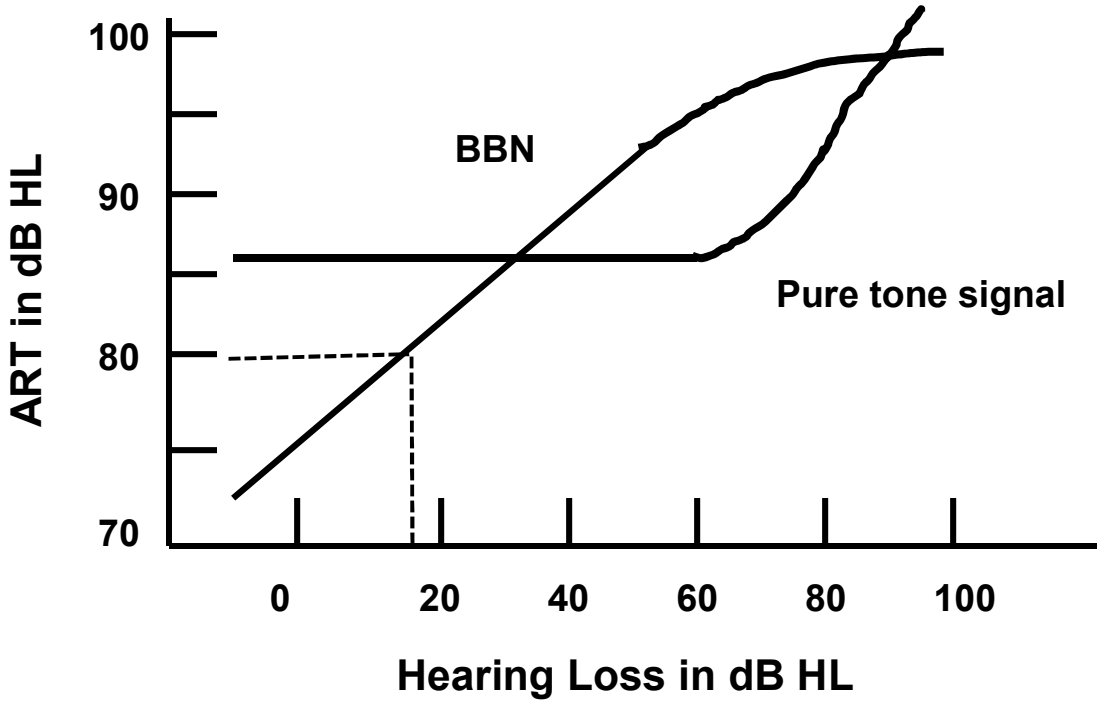
Noise-Tone Difference	BBN ART in dB SPL	Prediction
>20 dB	Anywhere	Normal
15 to 19	≤ 80	Normal
15 to 19	> 80	Normal-Moderate
10 to 14	Anywhere	Mild-Moderate
< 10	≤ 90	Mild-Moderate
< 10	> 90	Severe
AR not observed		Profound

Estimation of Hearing Thresholds with Acoustic Reflexes: A Sampling of Publications

- Hall JW III. Predicting hearing loss with acoustic reflexes. In Jerger J & Northern J (eds*). Impedance Audiometry* (2nd ed), 1980
- Hall JW III and Bleakney ME. Hearing loss prediction by the acoustic reflex: Comparison of seven methods. Ear and Hearing 2: 156-164, 1981
- Hall JW III. Hearing loss prediction in a young population: Comparison of seven methods. International Journal of Pediatric Otorhinolaryngology 3: 225-243, 1981
- Hall JW III and Koval C. Accuracy of hearing prediction by the acoustic reflex. The Laryngoscope 92: 140-149, 1982
- Hall JW III, Berry GA and Olson K. Identification of serious hearing loss with acoustic reflex data: Clinical experience with some new guidelines. Scandinavian Audiology 11: 251-255, 1982

Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)

Hall JW III, Berry GA and Olson K. Identification of serious hearing loss with acoustic reflex data: Clinical experience with some new guidelines. Scandinavian Audiology 11: 251-255, 1982



Simplified SPAR (Sensitivity Prediction by the Acoustic Reflex)

Hall JW III, Berry GA and Olson K. Identification of serious hearing loss with acoustic reflex data: Clinical experience with some new guidelines. Scandinavian Audiology 11: 251-255, 1982

Acoustic Reflex Threshold for BBN (dB HL)	N	Pure Tone Average for 500 – 4000 Hz in dB HL	
		< 35	≥ 35
58	2	100	0
63	6	100	0
68	20	100	0
73	32	100	0
78	51	69	31
83	76	76	24
88	66	55	45
93	39	28	72
98	25	16	84
≥ 103	9	0	100

Identification of Hearing Loss with Acoustic Reflexes Using Pure Tone vs. BBN Signals

(Popelka, 1981)

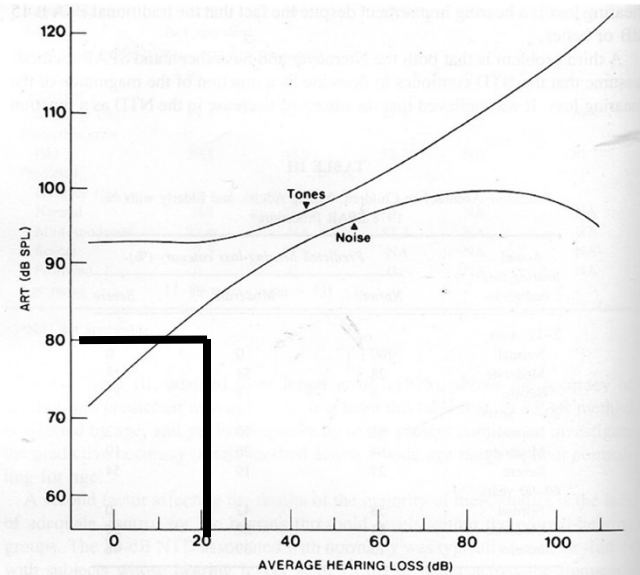


Fig. 2 Acoustic-reflex thresholds for tones (averaged over 500, 1000, and 2000 Hz) and for a BBN noise in dB SPL as a function of average hearing level for 500, 1000, and 2000 Hz in dB HL. The lines represent the best-fit functions. (Reprinted by permission of Popelka, G. R. The acoustic reflex in normal and pathologic ears. In G. R. Popelka (Ed.), *Hearing assessment with the acoustic reflex*. New York: Grune & Stratton, 1981, pp. 5–21. By permission of Grune & Stratton.)

Acoustic Reflexes in Neonates: Objective Differentiation of Normal Hearing versus Sensory Hearing Loss

- Kei J. Acoustic stapedial reflexes in healthy neonates: normative data and test-retest reliability. *JAAA, 23,* 2012
  - 66 full term infants
  - Acoustic reflexes recorded with 1000 Hz probe tone
  - Tone and BBN stimuli
  - All neonates had acoustic reflexes

Acoustic Reflexes in Neonates

(Kei J. Acoustic stapedial reflexes in healthy neonates: normative data* and test-retest reliability. *JAAA, 23,* 2012)

Stimulus	Median ART (dB HL)	90% Range
500 Hz	80	70 - 95
2000 Hz	70	60 - 85
4000 Hz	65	50 - 80
BBN	55	50 – 75

** N = 68 ears*

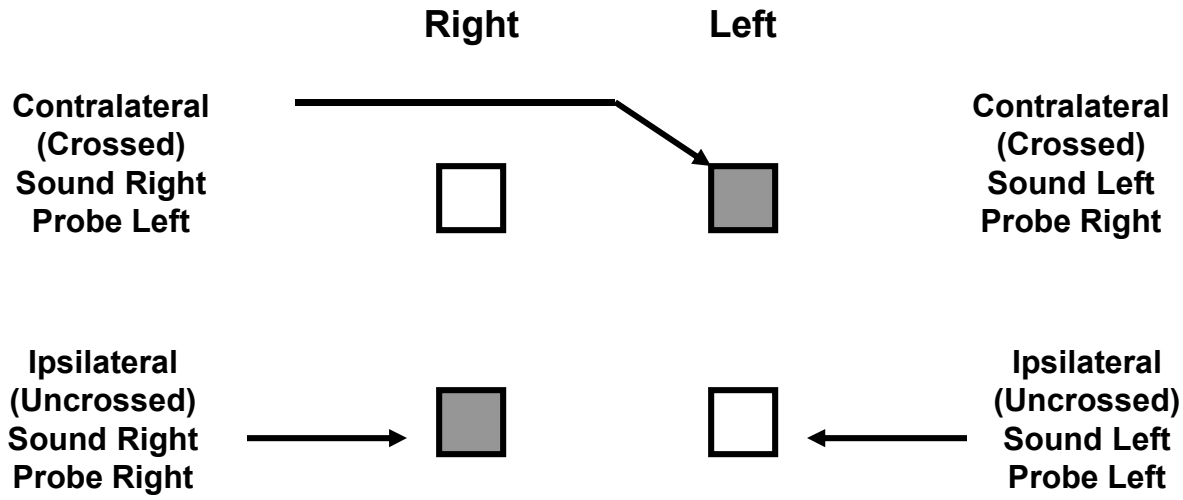
Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Normal hearing sensitivity versus sensory hearing loss**
  - **Detection of severe-profound sensory hearing loss vs. 8th nerve dysfunction**
  - **Detection of 7th nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized
Severe Sensory vs. 8th Nerve Pattern

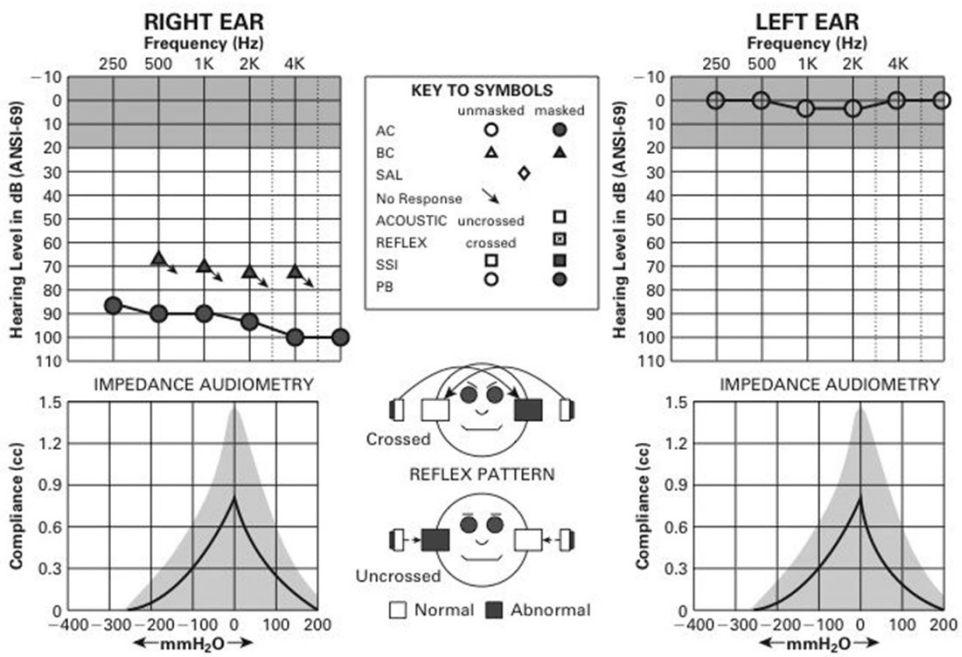
Abnormal Acoustic Reflex

DIAGONAL PATTERN
Severe unilateral sensory hearing loss *or* 8th nerve auditory dysfunction on right ear?

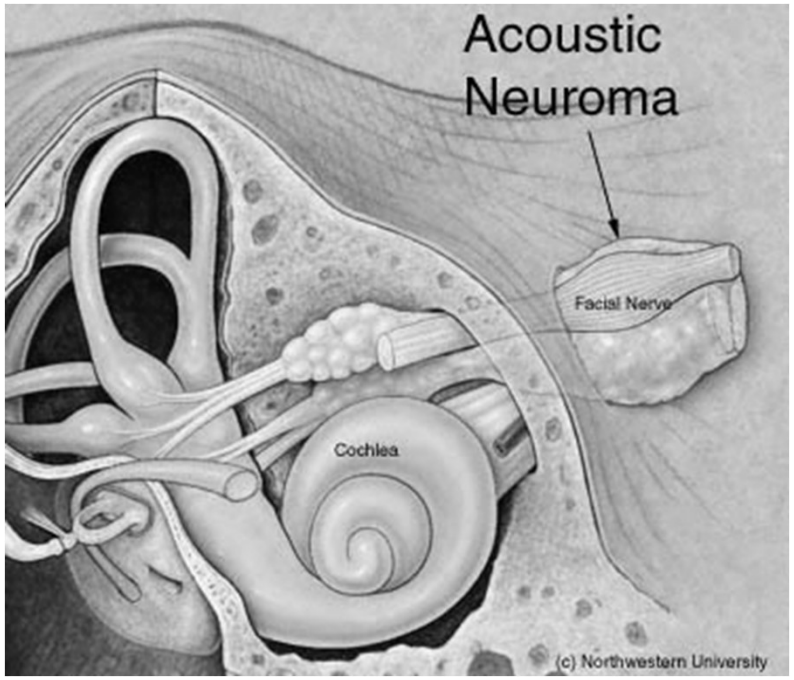


Plotting the Results of Acoustic Reflex Measurements

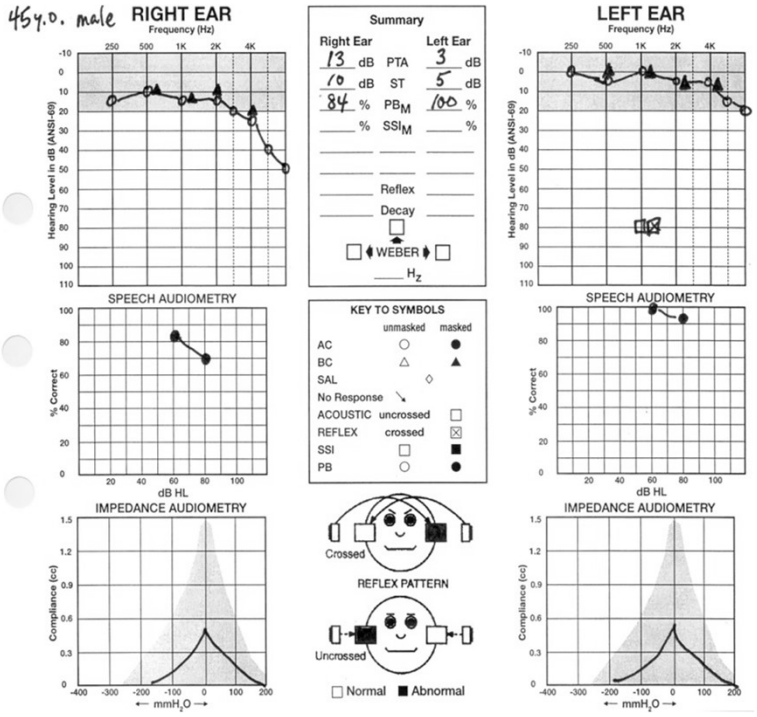
(From Hall JW III. *Introduction to Audiology Today*. Boston: Pearson, 2014)



Acoustic Reflex Pattern and Audiogram in 8th Cranial Nerve (Retrocochlear) Disorder



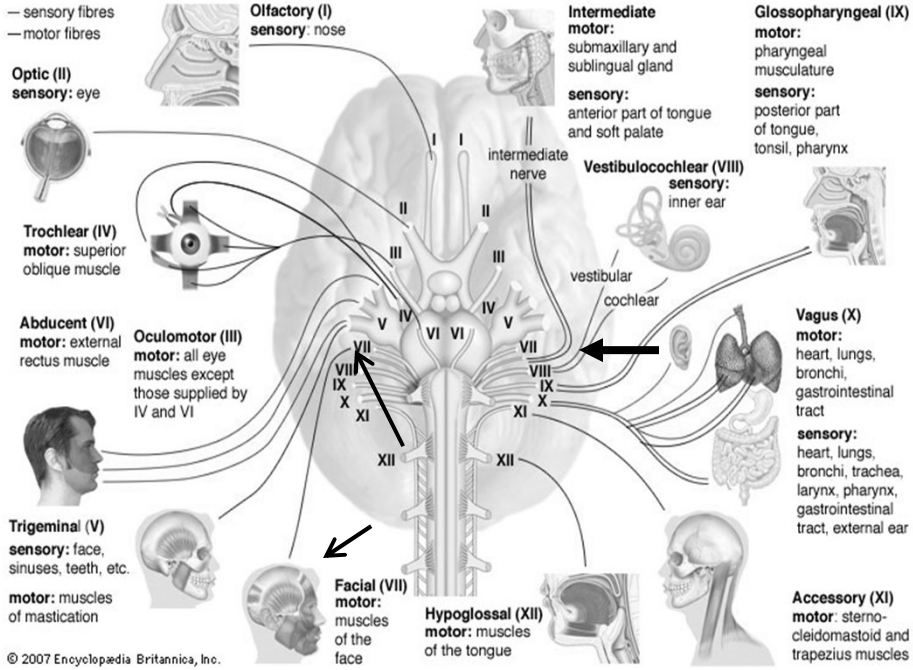
Audiogram and Acoustic Reflex Pattern:
8th Cranial Nerve Disorder



Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Normal hearing sensitivity versus sensory hearing loss**
  - **Detection of 8th nerve dysfunction**
  - **Detection of 7th (facial) cranial nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**
  - **Identification of false or exaggerated hearing loss**

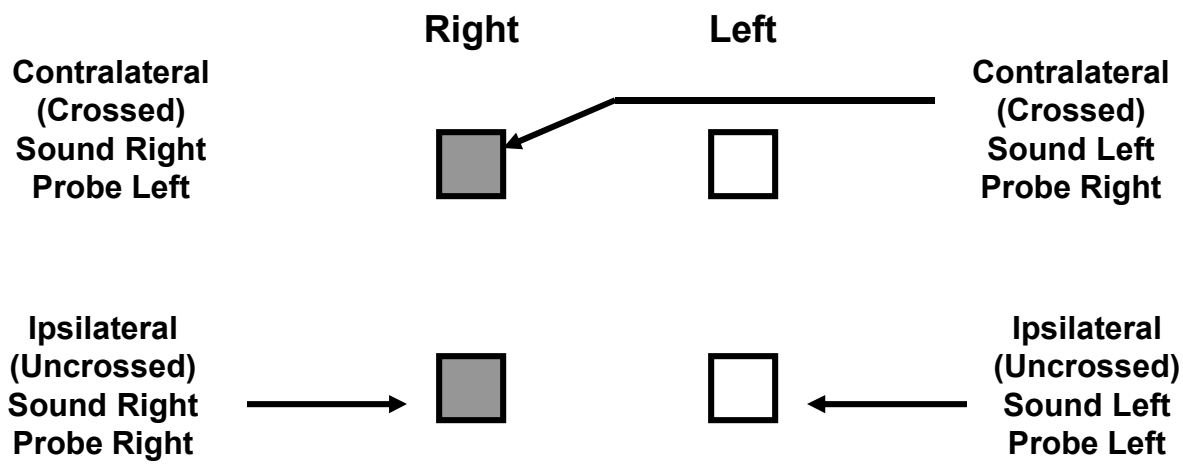
Facial Nerve:
7th Cranial Nerve



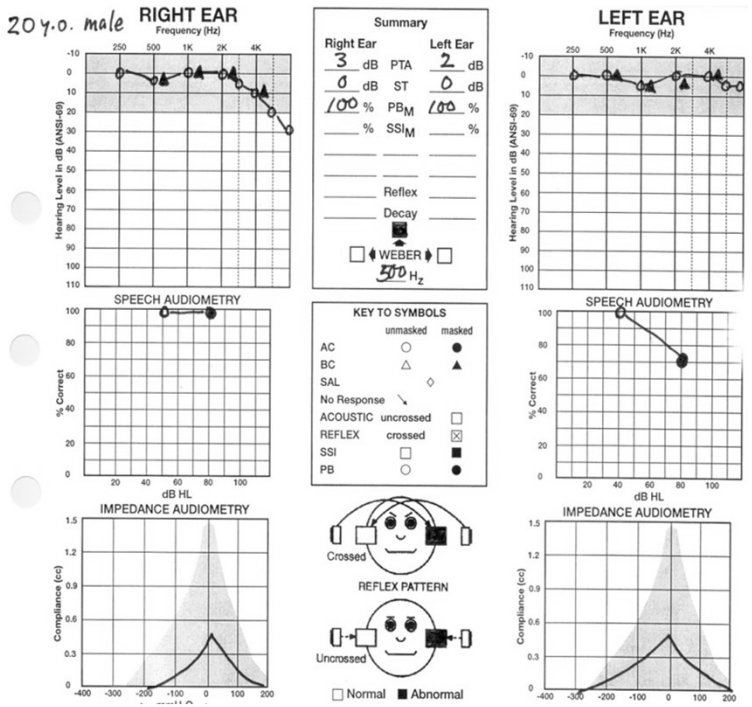
Plotting the Results of Acoustic Reflex Measurements

Abnormal Acoustic Reflex

VERTICAL PATTERN
Normal tympanogram? Normal OAEs?
Normal hearing sensitivity?
Efferent (7th CN) pattern



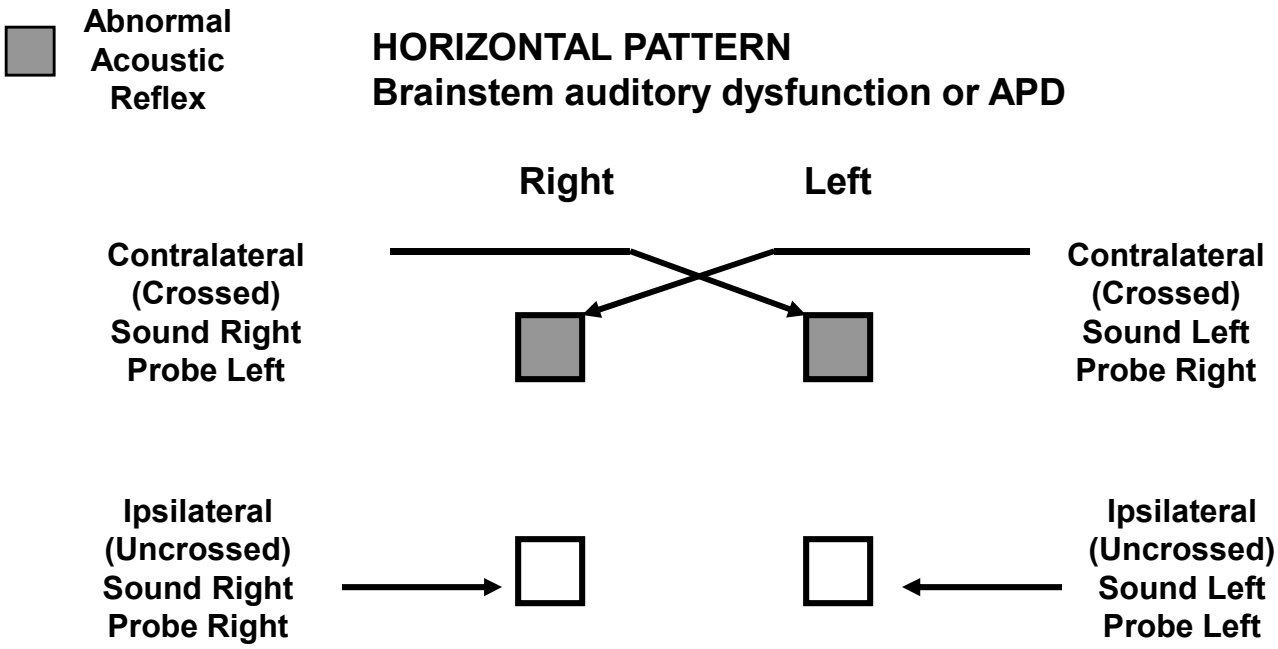
Audiogram and Acoustic Reflex Pattern:
7th Cranial Nerve Disorder (Left Side)



Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Normal hearing sensitivity versus sensory hearing loss**
  - **Detection of 8th nerve dysfunction**
  - **Detection of 7th nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**
  - **Identification of false or exaggerated hearing loss**

Plotting the Results of Acoustic Reflex Measurements



Plotting the Results of Acoustic Reflex Measurement:
The Unibox Pattern (Single Contralateral Reflex Absent)

A New Acoustic Reflex Pattern

Susan Jerger, MS; James Jerger, PhD; James Hall, MA

• A new crossed-vs-uncrossed acoustic reflex pattern has been observed in four patients with retrocochlear disorder. The new reflex pattern is characterized by a unique "uni-box" configuration. Reflexes are abnormal with sound to the affected ear on crossed stimulation only. In one additional patient, a variation of the uni-box pattern was found on suprathreshold reflex amplitude measures. We observed a large ear difference between reflex amplitude functions in the crossed condition, but not in the uncrossed condition. This observation suggests that reflex amplitude measures may be a valuable addition to threshold measures in some patients.

(*Arch Otolaryngol* 105:24-28, 1979)

diagnostically nonspecific inverted L-shaped pattern.

This article concerns the one exceptional reflex pattern. This unusual finding occurred[1] in a 53-year-old woman with a large acoustic schwannoma on the right side. At surgery, the tumor was noted to displace and distort adjacent brain stem structures. Figure 1 shows this patient's audiogram and acoustic reflex results. The audiogram shows a mild sensorineural loss in the right (eighth nerve) ear and normal sensitivity in the left ear. Pure-tone average (PTA) scores for 500, 1,000, and 2,000 Hz are 32 dB for the right ear and 1 dB for the left

sound to the affected ear on crossed stimulation only.

We first suspected that the reflex abnormality in this patient was due to middle ear disorder. However, bone conduction thresholds on both ears were superimposed on air conduction thresholds. Further, tympanometry showed normal, bilaterally symmetrical, tympanograms on both ears.

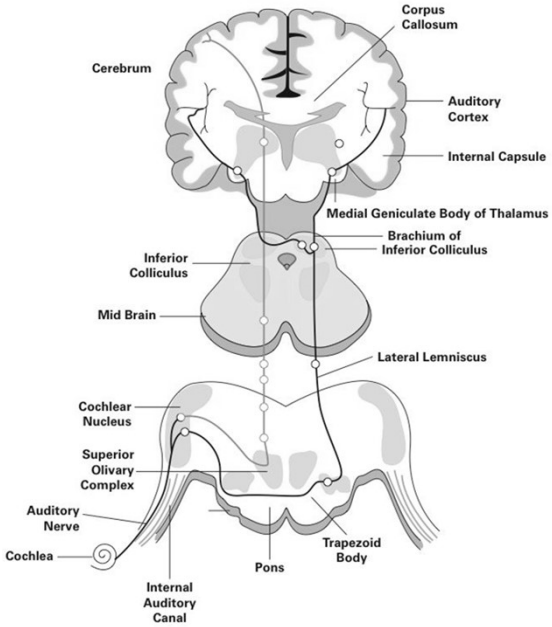
In short, we appeared to be observing a unique new reflex pattern. However, we were reluctant to regard this pattern as a distinct retrocochlear sign. Several possible explanations for this unexpected finding could not be adequately ruled out retrospectively, i.e., undetected middle ear disorder,

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Normal hearing sensitivity versus sensory hearing loss**
  - **Detection of 8th nerve dysfunction**
  - **Detection of 7th nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**
  - **Identification of false or exaggerated hearing loss**

Acoustic Reflexes in the Diagnosis of Auditory Neuropathy Spectrum Disorder (ANSD): *OAEs Normal and Acoustic Reflexes Absent*

- **Bielecki, Horbulewicz & Wolan. Prevalence and risk factors for auditory neuropathy spectrum disorder in a screening newborn population at risk for hearing loss. *Int J Pedi ORL, 76*, 2012.**
  - **5% of children with hearing loss diagnosed with ANSD**
  - **Acoustic reflexes played role in the diagnosis**



Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **Clinical Applications of Acoustic Reflexes**
  - **Detection of even subtle middle ear dysfunction**
  - **Normal hearing sensitivity versus sensory hearing loss**
  - **Detection of 8th nerve dysfunction**
  - **Detection of 7th nerve dysfunction**
  - **Detection of brainstem auditory dysfunction**
  - **Diagnosis of auditory neuropathy spectrum disorder**
  - **Identification of false or exaggerated hearing loss**

Applications of Acoustic Reflexes in the Assessment of False and Exaggerated Hearing Loss

- Other terms
  - Functional hearing loss
  - Pseudohypacusis
  - Non-organic hearing loss
- Risk factors for false or exaggerated hearing loss
  - Children
    - ✓Adolescent girls
    - ✓Trauma (physical, sexual, psychological)
  - Adults
    - ✓Potential compensation
    - ✓Legal action
    - ✓Trauma (physical, sexual, psychological)

Applications of Acoustic Reflexes in the Assessment of False and Exaggerated Hearing Loss

- Pattern of auditory findings
  - Normal otoacoustic emissions (OAEs)
  - Normal acoustic reflex thresholds for BBN signal
  - Hearing loss according to the audiogram
  - Discrepancy between PTA and SRT
  - Confirmation with other objective measures, e.g.,
    - ✓ABR
    - ✓ASSR
    - ✓Cortical auditory evoked responses

Assessment of False or Exaggerated Hearing Loss
Why Prompt Diagnosis is Important

- **Elimination of unnecessary health care costs. e.g.,**
  - **Radiological studies**
  - **Laboratory studies**
  - **Compensation for non-existent impairment**
  - **Referral to specialists**
- **Prevention of inappropriate treatment, e.g.,**
  - ✓**Medical**
  - ✓**Surgical**
  - ✓**Audiological**
- **Prompt intervention for underlying cause or factors**
  - **Counseling**
  - **Psychological or psychiatric management**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- The Long Clinical Tradition with Admittance Measurement
- Acoustic Reflex Measurement is Evidence-Based Practice
- Review of Anatomy and Physiology
- Variety of Acoustic Reflex Measurements
- Clinical Applications of Acoustic Reflexes
- CPT codes
- Summary of Advantages of Acoustic Reflexes in Clinical Audiology

Middle Ear and Acoustic Reflex Measurements: *Billing (CPT) Codes*

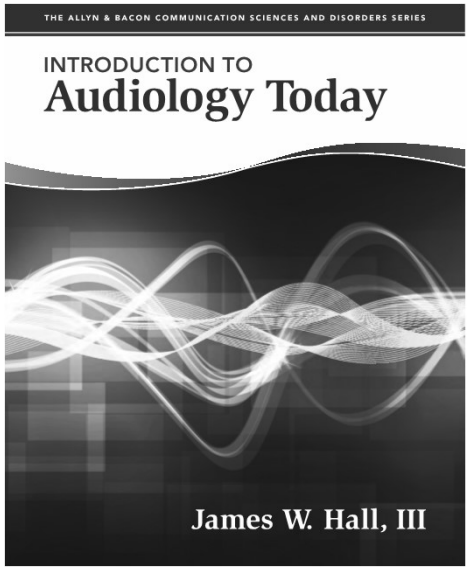
- **Deleted code**
  - **92569: Acoustic reflex testing, decay (deleted 2010)**
- **92567: Tympanometry (impedance testing)**
- **92568: Acoustic reflex testing, threshold**
- **92550: Tympanometry and reflex threshold measrrements**
  - **Do not report in conjunction with 92567 or 92568**
- **92570: Acoustic immittance testing, includes**
  - **Tympanometry (impedance testing)**
  - **Acoustic reflex threshold testing**
  - **Acoustic reflex decay testing**
  - **Do not report in conjunction with 92567 or 92568**

Acoustic Reflexes:
Diagnostically Valuable but Clinically Underutilized

- **0 – 5 minutes:**
  - **Introduction to historical perspective**
- **6 – 15 minutes:**
  - **Acoustic reflex anatomy and pathways**
- **16 – 40 minutes:**
  - **Acoustic reflex measurements in clinical audiology**
- **41 – 55 minutes:**
  - **Clinical applications of acoustic reflexes in children and adults**
- **56 – 60 minutes:**
  - **Questions and Answers**

Thank You!

Questions?



(https://www.pearsonhighered.com/program/Hall-Introduction-to-Audiology-Today)