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- Email customerservice@AudiologyOnline.com
ART Teaching Strategies for Clinical Preceptors

Diana C. Emanuel, Ph.D., CCC-A
Dept. Speech-Language Pathology & Audiology
Towson University

Learner Outcomes

1. List terms used to identify the ART test and the prevalence & currency of these terms and this test procedure.
2. Describe how teaching and learning taxonomy can be used to help students who may have an understanding of clinical testing but have difficulty with the analysis and creativity required for clinical application.
3. Describe how issues with ART equipment and terminology may result in miscommunication of ART results for both novice and experienced audiologists.
4. Describe ways in which preceptors can guide students in differential diagnosis, especially when patient ART results differ from expected "textbook" results.
ART or what?

Middle ear muscles

Acoustic Reflex (AR)/Acoustic Reflex Threshold (ART)
Stapedius Muscle Reflex or Stapedial Reflex
Middle Ear Muscle Reflex (MEMR)
Acoustic Middle Ear Reflex (AMER)
Acoustic Stapedial Reflex (ASR)

Relative prevalence of terms

1950—1960s
- Jensen (1951)
- Metz (1953)
- Wever & Vernon (1955)
- Hensel* (1878-1945)
- Kato* (1913-1946)
- Moller (1962)
- Geffcken* 1934-1954

1970s—1990s
- Anderson et al. (1970)
- Jerger & Jerger (1977)
- Moller (1974)
- Luscher* (1929-1934)
- Borg & Zakrisson (1975)
- Jerger & Jerger (1977)
- Silman & Gelfand (1981)
- Gelfand et al. (1990)
- Margolis (1993)
- Prasher & Cohen (1993)

2000s
- Sininger (2002)
- Berlin et al. (2005)
- Marlin et al. (2009)
- Hunter & Shahnaz (2013)
- Valero et al. (2016)
Relative prevalence of terms

![Graph showing relative prevalence of terms from 1975 to 1985 and from 2009 to 2019.]


Prevalence of terms

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Acoustic Reflex</td>
<td>675</td>
<td>1360</td>
</tr>
<tr>
<td>Acoustic Reflex Threshold</td>
<td>124</td>
<td>141</td>
</tr>
<tr>
<td>Stapedial Reflex</td>
<td>81</td>
<td>314</td>
</tr>
<tr>
<td>Middle Ear Muscle Reflex</td>
<td>18</td>
<td>89</td>
</tr>
</tbody>
</table>

*Library Database search included: Academic Search Ultimate + MEDLINE + CINAHL. Date of search: 04.23.19
Reported clinical use

Reported use of ART

- Martin & Forbis (1978)
- Martin & Sides (1985)
- Martin et al. (1994)
- Martin et al. (1998)
- Emanuel et al. (2012)

“We need to do reflexes...on everyone”

“We need to do reflexes, tympanometry, and OAEs on everyone...we have to adapt our clinical protocols...to allow us to screen for ANSD.” (Beck, 2012)

“The AMER ... is of tremendous importance ... and is often overlooked with regard to the vast wealth of diagnostic information revealed from this simple-to-measure and critically important audiologic measurement.” (Beck & Speidel, 2013)

“The acoustic reflex remains the only probe of central auditory function typically included in the standard battery...remarkably sensitive to retrocochlear dysfunction given the ease with which they can be obtained.” (Noel & Aiken, 2019)
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The trip to the basement
Taxonomy for Teaching and Learning

Bloom et al. (1956)
Revised by Anderson & Krathwohl (2001)

ART Foundations
Anatomy; physiology; pathology; terminology; dangers of high intensity signals

ABCs of ARTs (Emanuel, 2019)

Arrows & Heads

Boxes & Patterns

Cartoon Anatomy
ABCs of ARTs (Emanuel, 2019)

Arrows & Heads

Boxes & Patterns

Cartoon Anatomy

Sketch by Emanuel based on figures from multiple sources such as: (A) Jerger & Jerger (1977), (B) Lew et al. (1992), and (C) dozens of textbooks.
ABCs of ARTs (Emanuel, 2019)

Arrows & Heads

Boxes & Patterns

Cartoon Anatomy

ART art
ART art

ART art
ART art

Better ART art

Emanuel (2009)
ART tutorial (Emanuel, 2009)

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Stimulus-ear vs probe-ear orientation

- **Recent on-line quotes:**
  - There are two schools of thought… One is contra with reference to probe ear … some others consider contra with reference to stimulus ear.
  - … the situation is hopelessly confused.
  - There is a need for usage of a common method among audiologists as the interpretation varies depending on the method used.

- **AuD Students at TU (2019; n=3/28)**
  - Sometimes the inconsistencies between reporting contra are confusing because some clinics take contra as stimulus ear and others as probe ear.

---

**Emanuel (2004)**

![Pie chart showing 69% for stimulus ear, 29% for probe ear, and 2% for both.]
## Terminology provided in standards

<table>
<thead>
<tr>
<th>Standard number</th>
<th>Standard title</th>
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<tbody>
<tr>
<td>ANSI/ASA S3.6-2018</td>
<td>Specifications for audiometers</td>
</tr>
<tr>
<td>ANSI/ASA S3.7-2016</td>
<td>Method for Measurement and Calibration of Earphones</td>
</tr>
<tr>
<td>ANSI/ASA S3.22-2014</td>
<td>Specification of Hearing Aid Characteristics</td>
</tr>
<tr>
<td>ANSI/ASA S3.1-1999 (R2018)</td>
<td>Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms</td>
</tr>
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</table>

### ANSI/ASA S3.39-1987 (R2012)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Probe ear</td>
<td>An ear into which a probe is inserted and in which an acoustic-imittance measurement is made</td>
</tr>
<tr>
<td>Stimulus ear</td>
<td>The ear to which the acoustic-reflex activating signal is presented in order to elicit a middle-ear muscle reflex. The middle-ear muscle reflex is identified with respect to stimulus ear.</td>
</tr>
<tr>
<td>Ipsilateral reflex</td>
<td>The middle-ear muscle reflex that is elicited in the stimulus ear ...uncrossed reflex.</td>
</tr>
<tr>
<td>Contralateral reflex</td>
<td>The middle-ear muscle reflex that is elicited in the ear contralateral to the stimulus ear...crossed reflex.</td>
</tr>
</tbody>
</table>

Right contra = stimulus right/probe left
Left contra = stimulus left/probe right
**So what?**

<table>
<thead>
<tr>
<th>Stimulus</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsi</td>
<td>WNL</td>
<td>A/E</td>
</tr>
<tr>
<td>Contra</td>
<td>WNL</td>
<td>A/E</td>
</tr>
</tbody>
</table>

*Back to the Boxes (J&J, 1977)*

“Visual”

Crossed

Uncrossed

“*For visual description, four boxes represent probe ear*” (p. 449)

Note: This article was published 10 years before the first ANSI S3.39
Back to the Boxes (J&J, 1977)

Crossed Uncrossed
Probe right Probe left

Diagonal

"effect of left eigh nerve site of disorder"

Boxes & Patterns (J&J, 1977)

Crossed Uncrossed
Diagonal

Crossed Uncrossed
Horizontal

Crossed Uncrossed
Normal

Rotated Inverted Inverted L
Boxes & Patterns (J&J, 1977)

Jerger, Jerger & Hall (1979)

Boxes & Patterns

“Full house”

“In 6/8 cases, all ipsilateral and contralateral reflexes were elevated or absent across three adjacent frequencies (‘full-house’ pattern)” (*p. 5)


Problems with Boxes & Patterns

1. Learning

Memorize

Pattern x \rightarrow Pathology Y

2. Accuracy
Problems with Boxes & Patterns

Crossed

Uncrossed

Diagonal

Left VIII nerve

<table>
<thead>
<tr>
<th>Diagonal</th>
<th>Probe right</th>
<th>Probe left</th>
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<tbody>
<tr>
<td>Ips1</td>
<td>A/E</td>
<td>WNL</td>
</tr>
<tr>
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<td>A/E</td>
<td>WNL</td>
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</table>

<table>
<thead>
<tr>
<th>Vertical</th>
<th>Ips1</th>
<th>A/E</th>
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</thead>
<tbody>
<tr>
<td>Contra</td>
<td>A/E</td>
<td>WNL</td>
</tr>
</tbody>
</table>

Problems with Boxes & Patterns

Crossed

Uncrossed

Inverted L

<table>
<thead>
<tr>
<th>Inverted L</th>
<th>Probe right</th>
<th>Probe left</th>
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</thead>
<tbody>
<tr>
<td>Ips1</td>
<td>A/E</td>
<td>A/E</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inverted L</th>
<th>Stimulus right</th>
<th>Stimulus left</th>
</tr>
</thead>
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<tr>
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<td>A/E</td>
<td>WNL</td>
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<tr>
<td>Contra</td>
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</tbody>
</table>
Learning ART

- Questions for Au.D. students (Spring 2019; n=28)

- What did a professor or preceptor do that made ART concepts “click?”

- What concepts are/were difficult to learn?

What did a professor or preceptor do that made the concept “click?”

- Tracing the reflex pathway
  - Any type of visual colored diagrams
  - Using the arc, constant practice
  - Drawing of the reflex arc
  - The diagram! Marking up along the pathway!
  - Diagrams helpful (ART arc)
  - Drawing the pathway helped!
  - Drawing the pathway really helped
  - The diagram is so helpful
  - The tutorial was EXTREMELY helpful (thank you)
  - Drawing out pathways was extremely helpful
  - Having the diagram to look at when there was an abnormal pattern
  - Drawing out the pathways was helpful to learn how ARTs worked (drawing the pathway numerous times)
  - Preceptor explained the anatomy behind contra ARTs and I understood how and why we label them as such.
  - Preceptor took me through the reflex arc while performing the testing, which made the concept “click” for me.
What concepts are difficult?

- Differential diagnosis
  - Interpreting results when they don’t match other audiological tests
  - Difficult to understand why some people have normal hearing but absent ARTs.
  - Identify present reflexes that don’t look “textbook”
  - Linking etiologies with specific patterns
  - A lot of my clinical placements do not even do diagnostic ARTs.
  - Most supervisors perform them but don’t use results to hold much weight with diagnosis

- Communicating with patients
  - To a patient: how do you explain why we do ARTs?
  - Why do we have an acoustic reflex/does it protect our hearing?
  - Results of test
  - Ways to convey ARTs in a report (mainly for abnormal results).
  - Relating it back to the whole audiogram.

- Demonstrating skill under pressure
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Differential diagnosis

Why are reflexes absent?

Why are results weird?

When/how used?
Why are reflexes absent?

- Normal variability?
  - Possibly
  - Review literature on prevalence of missing reflexes and basic statistics textbook on confidence internals.
- Absent stapedius muscle?
  - Extremely unlikely (Berlin, 2012)
- Equipment failure?
  - Possibly
  - Take probe out, inspect for wax, try again
  - Test yourself/calibrate
- Test protocol?
  - Supra-aural earphones? → bilateral collapsing ear canal?
  - Infants? HF probe tone

AuD Student: “Most supervisors perform them but don’t use results to hold much weight with diagnosis.”
Why are reflexes absent?

- Aging?
  - Have student examine impact of aging in the literature (e.g., Silman 1988).

- Auditory deprivation?
  - No – it goes the other way by ~6 dB (Brotherton et al., 2019)

- Drugs?
  - Possibly
  - Have student examine PDR

Why are reflexes absent?

- Pathology
  - Retrocochlear pathology?
    - e.g., Jerger & Jerger (1977); Hayes & Jerger (1981)
    - Usually occurs with HL, ABN WRS, case hx.
  - Rare pathology?
    - E.g., Bamiou et al, 2001
    - Gaucher Disease Type 3 (lysosomal storage disorder)
    - Normal audio, OAEs, 100% elevated/absent reflexes (n=8), abnormal ABR, infant onset
  - Multiple Sclerosis?
    - E.g., Jerger et al. (1986)
    - Abnormality in reflex (controlled for age and hearing loss) in 75% of MS subjects with 30% of these having an elevated threshold for .5k, 2k (TB) or BBN signal.
Why are reflexes absent?

• Pathology
  • Otosclerosis?
    • E.g., González, et al. (2002)
    • No response or reversed response
  • Auditory/cochlear neuropathy/dys-synchrony
    • E.g., Berlin et al. (2005)
      • Auditory neuropathy/dys-synchrony: Abnormal reflexes for all patients tested (n=136)
      • Cochlear neuropathy: “MEMR may be valuable in the early detection of cochlear neuropathy...component of age-related hearing loss...noise-induced hearing loss...and other types of acquired sensorineural hearing loss.” (Valero et al., 2016, p. 29)

Why are reflexes weird?

• Normal variation in morphology?
  • Possible

• ARTs at intensity lower than expected?
  • Functional hearing loss?
  • Hyperactive acoustic reflex? (Downs & Crum, 1980).
Why are reflexes weird?

- Artifact?
  - Very likely, especially for ipsilateral testing
  - Rule out equipment failure, patient motion
  - Check probe and re-insert

- “Current admittance meters are much improved in their ability to reduce artifact [compared with equipment prior to the late 1970s]; however, artifact can still occur. It is more likely to occur during ipsilateral testing versus contralateral testing, especially when high intensity stimuli are used or the ear canal is very small (see Gelfand (2002) or Green & Margolis (1984) for a review).”
  Emanuel (2011)

Why are reflexes weird?

- Upward deflection
  - Reversed Ipsilateral Acoustic Reflex (RIAR)
    - Yavuz et al. (2007)
  - Inverted acoustic reflex (IAR)
    - Vallejo et al. (2009)
Why are reflexes weird?

- Yavuz et al. (2007): Retrospective study and review of literature
  - Prevalence of RIAR increases with hearing threshold
    - Opposite of AR tendency
  - Reflex latency findings indicate RIAR is not SM or TTM contraction.
  - RIAR recorded in ears unlikely to have a real AR:
    - Otosclerosis
    - Profound hearing loss
    - Dissected temporal bones
      - Damage to cochlear/vestibular fx
      - Resection of VIII nerve
      - Neuromuscular fx blocked by muscle relaxants.

Why are results weird?

Yavuz et al., (2007)

“The reversed acoustic reflex pattern is not an artifact but a physiologic event…This reflex does not appear to be related to stapedius or tensor tympani muscle contraction.” (p. 274).

Vallejo et al. (2009)

“The appearance of [IAR] in a corpse and its non-disappearance with muscular relaxation means that we consider its origin to be a purely mechanical effect not mediated by any muscular reflex contraction in the human middle ear.”
When/how used?

Emanuel litmus test: “What do you have to gain and what do you have to lose?”

- Do you understand the possible risks to your patients? (including infants with small ear canals)? (e.g., Emanuel et al., 2011; Hunter, 1999)

- Will your recommendations change as a result of the ART test?
  - Yes/Maybe (depends on the result)
  - No
When/how used?

Should I do immittance tests routinely?

YES

“It is absolutely best practice to always consider doing immittance tests, and to decide based on the patient’s needs, while balancing cost-effectiveness ... Have you ever been to a primary care physician who didn’t weigh you, do a blood pressure reading and listen to your heart, at a minimum, no matter what your complaint was?”

20Q: Acoustic immittance:
What still works & what’s new.
Audiology Online

When/how used?

Should I do immittance tests routinely?

- “Some patients with auditory neuropathy have normal audiometric thresholds, but ... in such patients the MEMR is often absent”

Valero et al., 2016
When/how used?

If I do ipsi, do I need to do contra?

IT DEPENDS

- Cross check for infants (w/ other tests)?
  - Ipsi
- New HL?
  - Ipsi & contra
- Complex/unclear case?
  - Ipsi & contra
- Suspect neural involvement?
  - Ipsi & contra

Audiology Online

What about Reflex Decay Testing?

- “The potential for causing harm outweighs the benefit of the test.”
  - Emanuel, 2012
  - audiologyonline.com/ask-the-experts/clinical-value-acoustic-reflex-decay-52

- “If there is a strong suspicion of the presence of an acoustic tumor, then ABR would be the diagnostic procedure of choice.”
  - Church (2004)
  - audiologyonline.com/ask-the-experts/reflex-decay-testing-554
Communicating with patients

- Checking a reflex with sound instead of a hammer.
- Omit description of protection from noise (confusing/inaccurate)
- Suggestions:
  - Get out of the weeds: focus on overall findings
  - Does your physician describe all individual results from a blood panel?

Thank You

ART Teaching Strategies for Clinical Preceptors

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demanuel@towson.edu
References


References


- Emanuel (2019). ABCs of ARTs. Personal communication.


References


References (continued)

References


