Unlocking the Cortex HEARLab® ACA (Aided Cortical Assessment) for Everyday Clinical Use

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Key Takeaways

Key Takeaway	Clinical Implication
Present CAEP = audible	A present CAEP is reassurance that speech is audible with the current fitting.
Absent does not always mean inaudible	Up to 23% of CAEPs were absent in audible infants. Cross-check sounds, levels, visits and the PEACH questionnaire.
A workable protocol	Two levels and three sounds, within 8 weeks of fitting and in one appointment.
Well received	The clinicians are satisfied, and the parents value the evidence.
Four key areas of use	Fitting evaluation, unaided audibility in ANSD, CI candidacy, and parent counselling (after the PEACH questionnaire).
ACA complements behavioral testing	ACA does not replace behavioral audiometry. It is a complementary physiological measure that reduces uncertainty while behavioral information is limited.
Know the limits	ACA is not for threshold estimation, speech discrimination or unguided CI testing.

Course Content

Learner Outcomes

- After this course, participants will be able to identify the clinical applications of HEARLab® ACA (Aided Cortical Assessment) in objectively evaluating auditory cortical responses to speech stimuli, particularly in infants and patients with limited or unreliable behavioral responses.
- After this course, participants will be able to describe the HEARLab® ACA testing protocol, including speech stimuli, free-field presentation, EEG recording, artifact rejection, and statistical response detection.
- After this course, participants will be able to interpret aided cortical auditory evoked potential (CAEP) results, distinguishing statistically detectable cortical responses from absent responses and recognizing the clinical limitations of the assessment.
- After this course, participants will be able to explain how HEARLab® ACA complements electroacoustic verification and behavioral audiometry in assessing hearing-aid fitting effectiveness, drawing on published evidence and established Australian clinical experience.

Why Objective Evaluation Is Needed

In an infant, we can often establish that hearing loss is present, but it is considerably more difficult to establish whether the fitted hearing aid is actually making important speech information audible. Hearing screening with no intervention strategies does not offer valuable assistance.

Four Reasons Infant Hearing-Aid Assessment Is Hard

Challenge	Why it matters
Limited behavioural information	Young infants cannot give consistent voluntary responses. Reliable VRA (Visual Reinforcement Audiometry) thresholds need developmental cooperation, so fittings rest on limited data.
Thresholds are only estimates	ABR, ASSR (Auditory Steady State Responses), OAE (Otoacoustic Emissions) and behavioral thresholds describe the auditory system, not whether amplified speech is audible at the cortex.
The hearing aid adds uncertainty	Electroacoustic verification shows what the aid delivers, not whether the infant's auditory system responds to it.
Infants cannot report audibility	An adult can say "I hear /m/ but not /t/." An infant cannot, so audibility across the speech spectrum has to be inferred.

Why Infant Hearing-Aid Fittings Need Objective Evaluation

Behavioral testing is unreliable before about 6 to 8 months of age, yet the hearing-aid fitting must be confirmed for each child. Three factors add uncertainty:

- ABR-based thresholds: estimating thresholds from auditory brainstem responses carries uncertainty.
- Ear canal size: small, variable infant ear canals change what the aid delivers.
- Population averages: fitting software prescribes from averages, not the individual child.

> **Objective evaluation can:**
>
> - Confirm that the hearing-aid fitting allows detection of conversational-level speech.
> - Show where fine-tuning is still needed.
> - Support the path to cochlear implantation when the loss is too severe.
> - Demonstrate aided benefit to parents.

Where ACA Fits

ACA occupies the gap between hearing-aid fitting and reliable behavioral assessment. All three post-fitting stages (electroacoustic verification, aided cortical assessment, and behavioral aided assessment) feed ongoing optimization of the fitting.

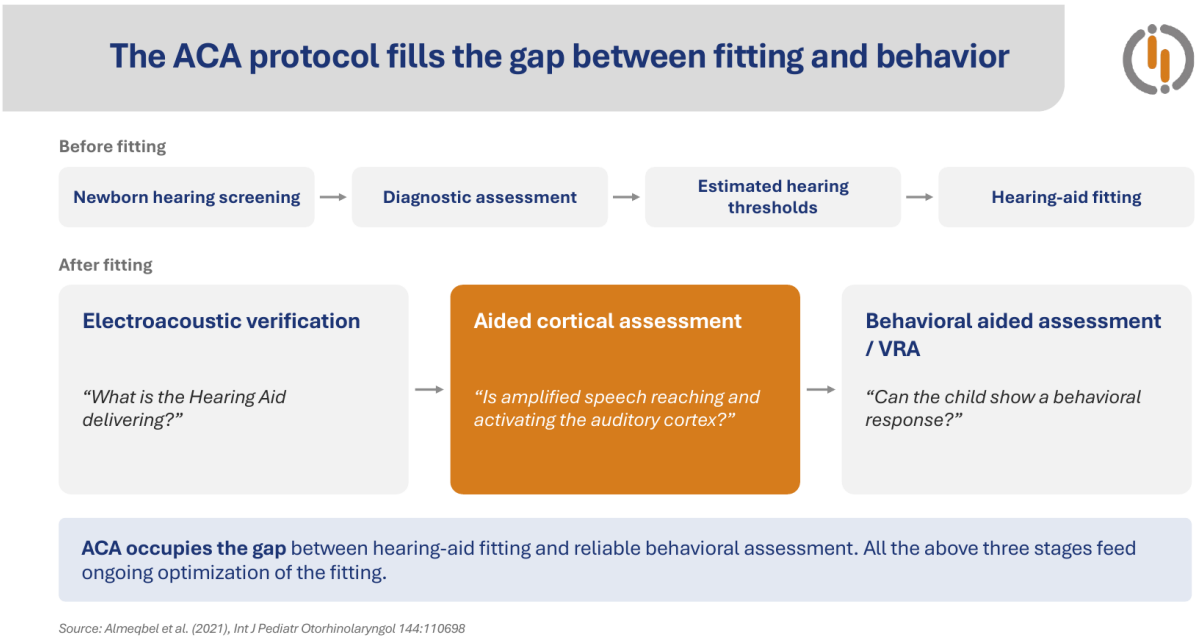


Figure 1. Where aided cortical assessment fits between hearing-aid fitting and behavioral assessment.

Six Clinical Scenarios Where ACA Can Contribute

Clinical scenario	How ACA contributes
Infants too young for behavioural tests	Below about 8 months VRA is not reliable. ACA confirms that aided speech sounds reach the cortex, so fittings are verified early.

Clinical scenario	How ACA contributes
Auditory neuropathy spectrum disorder (ANSD)	ABR cannot estimate thresholds in ANSD. Aided cortical responses show whether amplification gives access to speech.
Complex needs or unreliable responses	Developmental delay, multiple disabilities, or adults with cognitive impairment who cannot respond consistently.
Hearing aid or cochlear implant?	Absent aided responses despite a verified fitting support early CI referral; present responses support continuing with aids.
Fine-tuning hearing aid settings	Compare responses to /m/, /g/, /t/ across settings, for example with and without frequency compression, to confirm high-frequency audibility.
Cochlear implant follow-up	Checks cortical access to speech after activation in children who cannot yet report what they hear.

The Technology: What ACA Measures

CAEPs are responses of the auditory cortex to acoustic stimuli. The HEARLab ACA protocol records and analyses them, with built-in statistics that decide whether a response is present, so testing does not require an expert electrophysiologist.

- Active electrode: near the vertex.
- Reference electrode: near either mastoid.
- Ground electrode: on the forehead.
- Stimuli are presented in the free field through a loudspeaker, so the hearing aid processes them exactly as it would real speech.

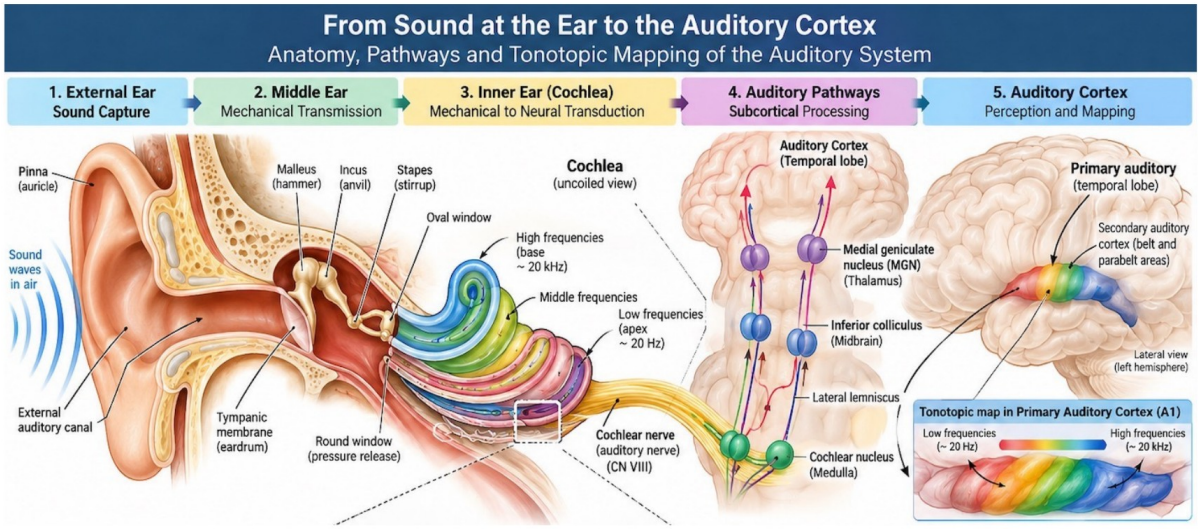


Figure 2. Anatomy, pathways and tonotopic mapping of the auditory system.

What ACA Adds to ABR and ASSR

Advantage	Description
Speech-like stimuli	Acoustic features relevant to speech can be used, and hearing aids handle them reasonably well.
Whole pathway	Integrity of the pathway up to the cortex is assessed, so presence correlates better with perception.
ANSD	A CAEP may be observed even when the ABR is absent. This is not contradictory: an absent ABR does not necessarily mean that auditory information cannot travel through the brainstem. It may mean that the neural activity is insufficiently synchronized to generate a detectable ABR.
Awake infants	Reliably recorded in awake normal-hearing infants at suprathreshold levels. The infant must be awake and relatively quiet, but does not need to be attentive to the auditory stimuli.

The ACA Speech Stimuli

Stimulus	Frequency region	Frequency range	Duration
/m/	Low frequency	200 to 500 Hz	30 ms
/g/	Mid frequency	800 to 1600 Hz	20 ms
/t/	High frequency	2000 to 4000 Hz	30 ms
/s/	Very high frequency	5500 to 8000 Hz	50 ms

Levels: 55, 65 and 75 dB SPL. The Australian ACA protocol uses /m/, /g/ and /t/ only.

The CAEP Waveform: P1, N1 and P2

The waveform is developmentally shaped and must be interpreted in context.

- P1: the dominant early cortical component in infants; latency and morphology change markedly with maturation.
- N1 and P2: later components become more clearly expressed with maturation; morphology is not identical to adult CAEPs.
- Clinical point: do not judge an infant waveform using adult latency or amplitude expectations alone.

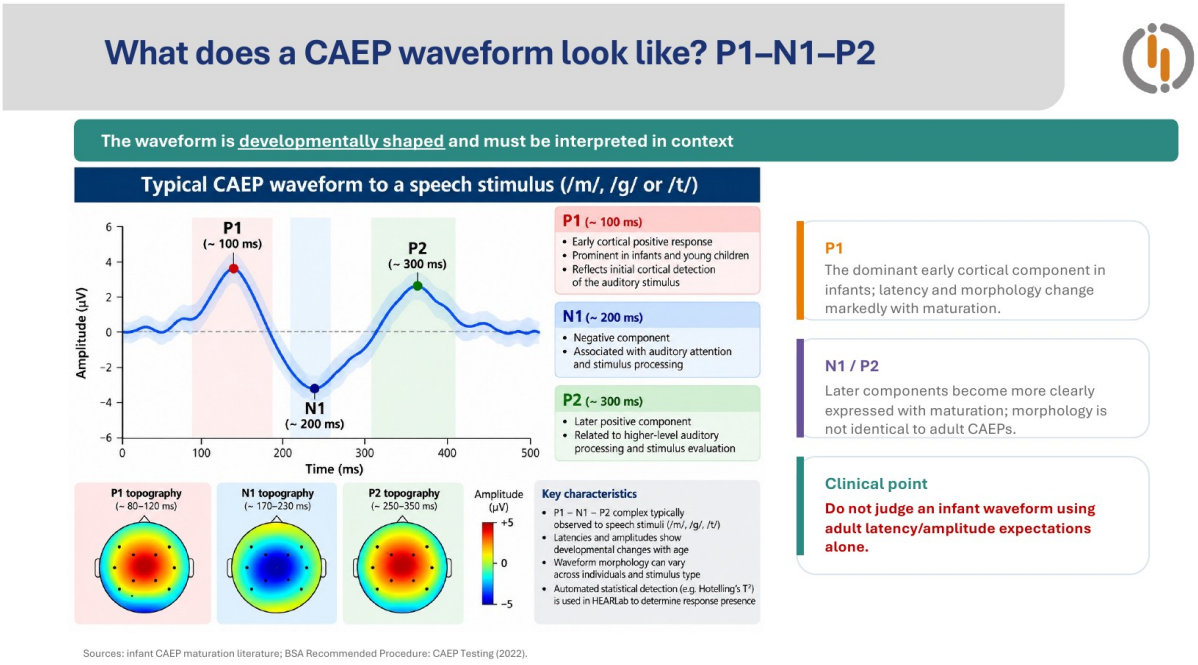


Figure 3. Typical CAEP waveform (P1, N1, P2) to a speech stimulus, with scalp topography.

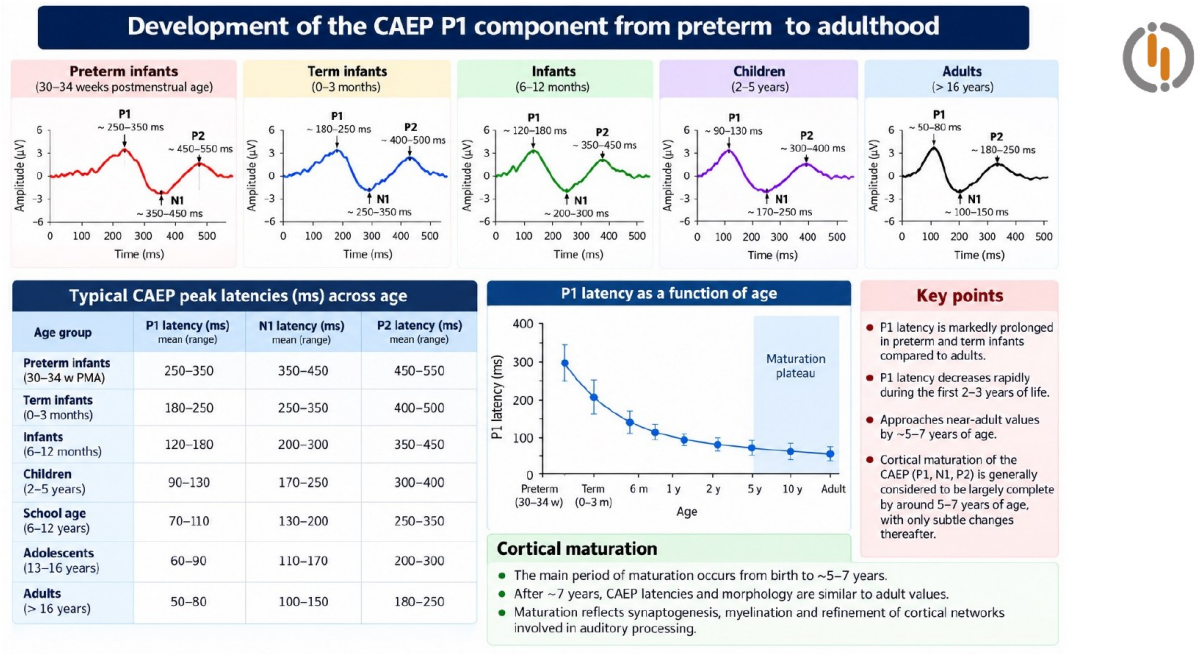


Figure 4. Development of the CAEP P1 component from preterm infants to adulthood.

Cortical Access, Not Comprehension

What ACA measures	What ACA does not measure
A cortical auditory evoked potential (CAEP) to a speech stimulus. Physiological evidence of neural activity at the cortex. The response with the infant wearing the hearing aid.	Speech understanding or comprehension. A complete, frequency-by-frequency audiogram. How the child will perform behaviourally.

ACA provides evidence of cortical access to amplified speech, not evidence of speech comprehension.

Q1 **Quiz Hint:** Aided CAEPs are most informative when behavioral responses cannot be obtained. They show whether amplified speech is reaching the auditory cortex in infants too young for VRA and in children with ANSD, where ABR cannot estimate thresholds.

Hardware and Recording Setup

Two systems are shown in the course: the HearLab (2010, 2011, 2012) from Frye Electronics, US, and the Celesta ACA from Inventis. Celesta can test four phonemes (/m/, /g/, /t/, /s/) in a free field at the same intensity level. Stimuli can be prioritized according to the clinical question and patient state, to optimize test time, and are presented in sequence, not simultaneously.

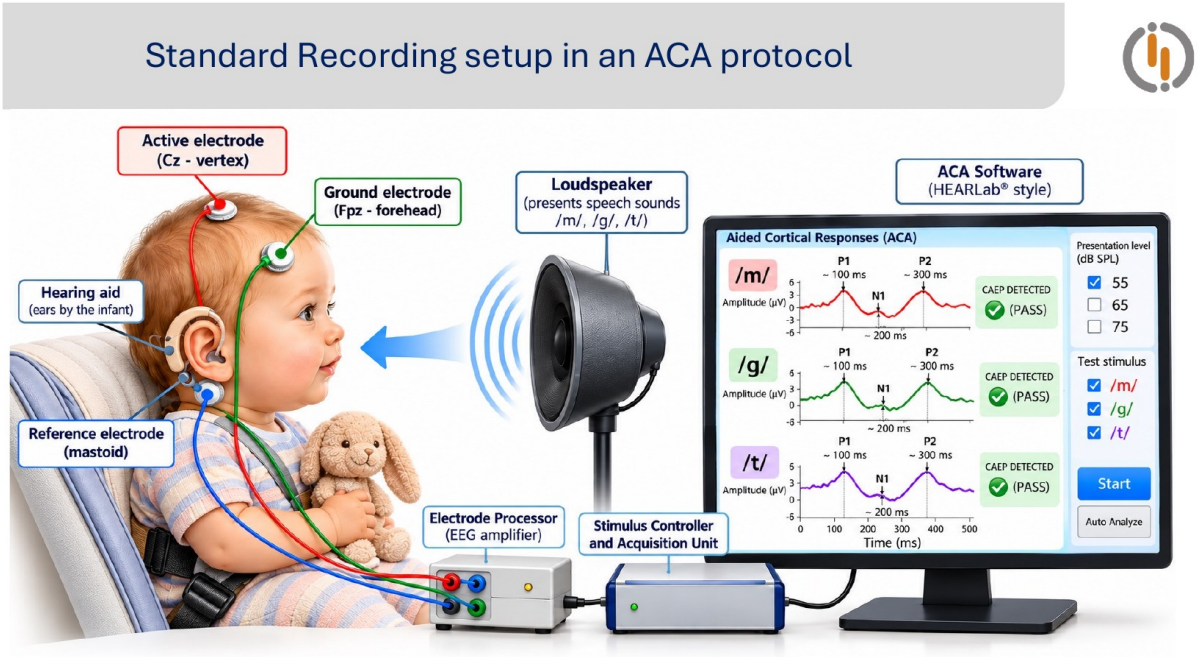


Figure 5. Standard recording setup in an ACA protocol.

The critical parameter is the stimulus intensity at the test ear, rather than the absolute loudspeaker distance or angle. Nevertheless, the 1 m distance has two advantages:

- It gives a relatively stable free-field geometry. Small movements of an infant's head produce relatively smaller proportional changes in sound pressure than they would at, for example, 20 cm.
- It approximates a far-field listening configuration. This is particularly useful when assessing the hearing aid's microphone response rather than delivering sound directly into the ear.

Presentation Level and Sensation Level

CAEP detection is strongly influenced by the stimulus level relative to the child's aided threshold. Presentation level is the acoustic level delivered in the sound field (55, 65 or 75 dB SPL). Sensation level (SL) is approximately the presentation level minus the aided threshold, and expresses how far above threshold the stimulus is.

Presentation level	Aided threshold	Sensation level	Meaning
65 dB SPL	45 dB	+20 dB SL	Strong opportunity for detection
65 dB SPL	65 dB	0 dB SL	Detection becomes less reliable
65 dB SPL	75 dB	-10 dB SL	Stimulus is below estimated aided threshold

Clinical message: interpret CAEP results alongside aided thresholds and the actual hearing-aid fitting, not from SPL alone.

How the System Determines a CAEP

The PASS result is a statistical decision. The chain runs: speech stimulus, EEG recording, artifact rejection, averaging, statistical detection, and interpretation.

- Speech stimulus: repeated /m/, /g/ or /t/ is presented while the infant wears the hearing aid.
- EEG recording: cortical activity is recorded from scalp electrodes together with background EEG noise.
- Clean epochs: movement, muscle activity and other artefacts are rejected; usable responses are retained.
- Statistical test: the response pattern is compared with residual background activity using an objective detection statistic.
- PASS or FAIL: PASS is a statistically detectable response. FAIL is no statistically detectable response in a valid recording.

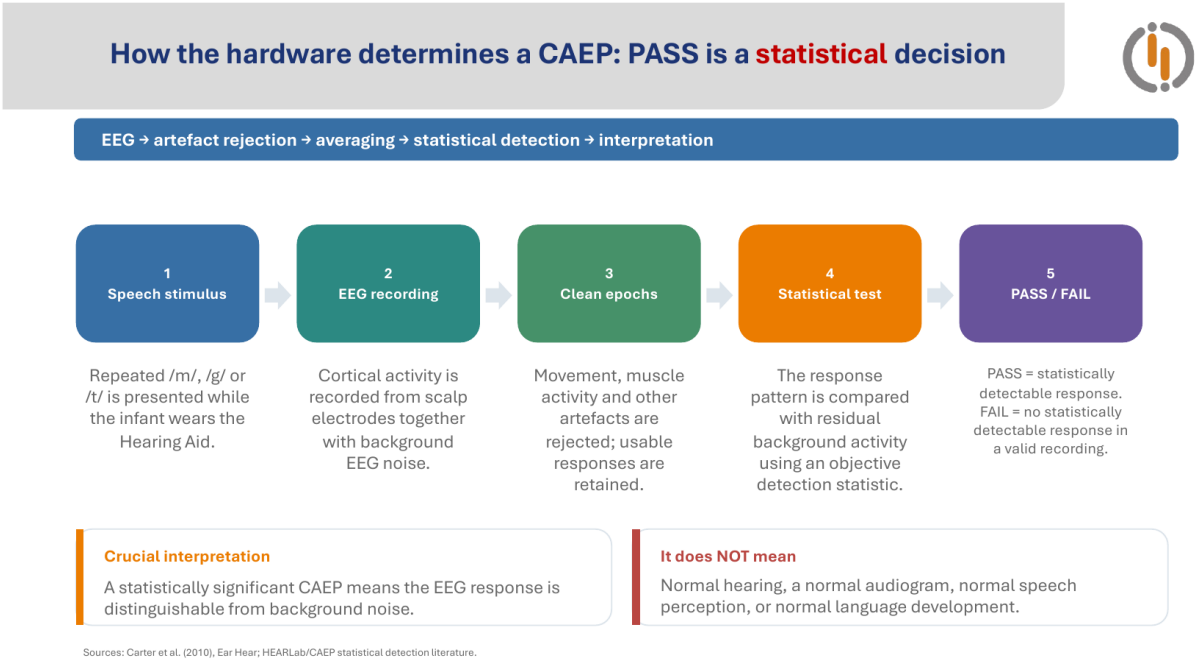


Figure 6. How the system reaches a PASS or FAIL decision for a CAEP.

A statistically significant CAEP means the EEG response is distinguishable from background noise. It does not mean normal hearing, a normal audiogram, normal speech perception, or normal language development.

Q3

Quiz Hint: A statistically significant CAEP means the EEG response is distinguishable from background noise, so the stimulus produced detectable activity at the auditory cortex under the test conditions. It does not mean normal hearing, a normal audiogram, normal speech perception, or normal language development.

What the Literature Tells Us

- A strong positive correlation was observed between CAEP scores and PEACH questionnaire results ($r = 0.884$, $p < 0.001$).
- The high correlation between aided CAEPs to speech at 55 dB SPL and aided behavioral thresholds in children with hearing loss suggests that cortical responses can anticipate what the child might show later via VRA.
- A CAEP is not a VRA response. A CAEP indicates that an acoustic stimulus has elicited measurable activity at the auditory cortex. VRA requires considerably more: the child must detect the stimulus, attend to it, learn the sound-visual reinforcement association, and produce a conditioned head-turn response.

Why a CAEP may be present while VRA is absent	Explanation
Developmental delay	Cortical sound detection may be preserved, but the child may not yet have the cognitive or motor maturity required for conditioned VRA.
Autism spectrum disorder (ASD)	Some children have atypical attention, sensory processing, or difficulty establishing the conditioning required for VRA. CAEPs may nevertheless be recorded.
Cerebral palsy	Auditory cortical processing may be preserved while motor limitations interfere with the head-turn response.

ACA gives evidence months before VRA is possible. In one example, an infant at 3 months has a diagnosed hearing loss and a fitted hearing aid but cannot reliably perform VRA, so ACA can show cortical access at that point in time. At 10 to 12 months a second infant can take part in VRA and behavioural data confirm the fitting. 103 infant hearing-aid users aged about 3 to 7 months were tested for ACA sensitivity, repeatability and feasibility before later behavioural assessment.

Using the ACA protocol, the median age at hearing-aid fitting decreased from 9.2 months without ACA to 3.9 months with ACA in the pathway. Early auditory stimulation is time-sensitive: ACA lets the fitting be corrected months before behavioural testing would reveal a problem.

CAEP present	CAEP absent
Evidence of cortical detection. The speech stimulus passed through the hearing aid, cochlea and auditory pathways and produced activity at the auditory cortex.	"We did not detect a cortical response." It does not mean the infant cannot hear the stimulus. An absent response needs investigation; it is not proof of inaudibility, because many technical factors can result in a lack of CAEP statistical presence.

In hearing-impaired infants tested with /m/, /g/ and /t/, CAEP detection rose as sensation level increased. Detection indicates audibility, but the logic only runs one way.

Where ACA Fits in the Clinical Toolbox

Measure	Asks	Measures
Electroacoustic verification (device: hearing aid or CI)	"What does the hearing aid or CI produce?"	Hearing-aid output under specified acoustic conditions.
Aided cortical assessment (cortex)	"Does the amplified signal activate the auditory cortex?"	A cortical statistical detection of the amplified speech stimulus.
VRA and aided behavioural thresholds (behavior)	"What response can the child demonstrate?"	Behavioural response to the stimulus.

These three protocols are complementary, not competing: each answers a question the other two cannot.

ACA does not replace behavioral audiometry. It is a complementary physiological measure that reduces uncertainty while behavioral information is limited. The integrated infant pathway runs through diagnostic audiology, electroacoustic verification, ACA/CAEP, behavioural aided assessment, and functional and parental measures.

Q5

Quiz Hint: ACA occupies the gap between hearing-aid fitting and reliable behavioral assessment. It is a complementary physiological measure that shows whether amplified speech is activating the cortex while behavioral information is limited, and it does not replace electroacoustic verification.

What ACA Adds to the Clinical Assessment Toolbox

- Objective: no behavioural response is needed from the infant.
- Cortical: shows neural activation at the cortex, not just hearing-aid output.
- Speech-specific: uses speech stimuli rather than pure tones alone.
- Aided: measured while the infant wears the hearing aid.
- Early: informative before reliable VRA is available.
- Comparative: compares responses across stimuli and presentation levels.

Part of the initial fitting program	Not a priority
Infants fitted from an audiogram estimated with tone-burst ABR or ASSR (mostly UNHS referrals). Children with ANSD (aided and unaided CAEPs). Any age with additional disabilities limiting behavioral information. Candidates for cochlear implantation.	Unilateral hearing loss. Three-frequency average loss below 45 dB HL. A 45 dB HL loss leaves a 10 dB sensation level for a 55 dB SPL speech sound, so a CAEP is likely even unaided, making aided and unaided conditions hard to compare.

What ACA Should Not Be Used For

- Threshold estimation: presentation levels are limited and stimuli are in the free field.
- Speech discrimination: ACA cannot show whether the cortex distinguishes two speech sounds.
- "Unguided" CI testing: not recommended. Always be wary of implant artifacts in recordings.

The Clinical Protocol

Step	Timing	Description
1. Fitting	At fitting	Hearing aids fitted to the national pediatric protocol.
2. Review	Within 2 weeks	Support and encouragement for the family.
3. Follow-up	4 to 6 weeks later	Evaluate the fitting: the time for aided CAEPs.
4. Adjust and re-test	As needed	Re-estimate the audiogram, re-fit, repeat CAEPs if needed.

Aided CAEP evaluation is typically completed within 8 weeks of the initial fitting. The first test is aided, unless the child has ANSD.

Running the Test in the Clinic

- Three brief stimuli, in the free field: /m/ 30 ms (about 250 Hz), /g/ 21 ms (about 1250 Hz), /t/ 30 ms (about 3250 Hz).
- Start at 65 dB SPL, then move to 55 or 75 dB SPL.
- Time to completion: fits a standard appointment. Test duration varies with the number of stimuli, patient state and clinical question; stimuli can be prioritized when needed.

Infant Recordings Depend on Maturation and State

Maturation: the infant auditory cortex is still developing	State of the subject: infants are not passive recording subjects
CAEP morphology and latency change with age; the P1 changes most. Consider the waveforms in terms of age, stimulus, recording conditions and developmental status. Adult criteria regarding the latency of the waveforms do not apply.	Movement, crying, sucking and muscle activity degrade the EEG. Arousal changes alter response quality. In 98 infants most were testable, and /m/, /g/, /t/ detection was high in evaluable ears.

ACA is an objective measure with recording limits, not an automatic "objective audiogram."

What If CAEPs Remain Absent After Adjustment

- Check the 75 dB SPL speech-o-gram. If no detection was expected in that range, the result is consistent with expectations.
- Use the PEACH (Parents' Evaluation of Aural/Oral Performance of Children). If the audiogram is already poorer, parents' observations show whether the child responds to sound in daily life.
- Rule out simple causes: middle ear disease (check before testing), arousal, noise.
- Consider CI referral: consistent absence across sounds, levels and visits, with PEACH, supports a CI candidacy evaluation.

Interpreting ACA Result Patterns

The core premise: a CAEP appears when a sound is above threshold (presence reflects audibility), and CAEP amplitudes increase with increasing hearing-aid gain in hearing-impaired adults and children. An absent CAEP therefore warrants further investigation of stimulus audibility, hearing-aid fitting and recording conditions, before clinical conclusions are drawn.

Result	Meaning	Action
Present	The detection statistic is significant: the sound reached the cortex.	Evidence of cortical detection.
Absent	Not significant, with residual noise low enough for a valid test.	Check audibility clinically (ABR/ASSR), then repeat the test.
Inconclusive	Noise too high to decide (too many rejected epochs during acquisition). The result says nothing about audibility.	Repeat when the infant is settled.

An Absent CAEP Has Many Possible Causes

Stimulus and fitting	Recording	Infant status	Analysis
Insufficient stimulus audibility. Poor hearing-aid fitting. Inadequate sensation level.	Infant movement. Muscle artefact. EEG noise. Poor electrode contact.	Unfavorable behavioral state. Sleep and state effects. Immature cortical responses. Individual variability.	Too few stimulus presentations. Statistical detection limits.

Only the stimulus and fitting group points to the hearing aid. Present responses are evidence of cortical detection; for absent responses, investigate before concluding the stimulus was inaudible.

Up to 23% of CAEPs were absent in hearing-impaired children aged 8 to 30 months even though speech was presented at audible levels (55, 65 or 75 dB SPL). Possible reasons (not all verified) include high noise levels, varying alertness, severe ANSD, small CAEPs (skull morphology, thickness, cortical folding), cortical maturation, poor speech perception or discrimination, and middle ear disease (check beforehand).

Q4 **Quiz Hint:** An absent CAEP warrants further investigation of stimulus audibility, hearing-aid fitting and recording conditions before clinical conclusions are drawn. Noise, infant state and other technical factors can cause an absent result, so cross-check before changing the fitting.

Always Cross-Check

- Several sounds: test stimuli with different frequency ranges, never one sound in isolation.
- Several levels: present at more than one level to build a consistent picture.
- Look further: no responses to three sounds despite an adequate fitting? Search for other causes (middle ear, ANSD, delayed cortical maturation).

Result Patterns Across Sounds

Pattern	/m/	/g/	/t/	Possible clinical interpretation
All three present	Present	Present	Present	Strong evidence of cortical access. Amplified speech reaches the cortex for all three sounds; at 55 dB, evidence that soft speech is audible.
/m/ absent	Absent	Present	Present	Possible low-frequency audibility problem, or stimulus-specific variability. Check low-frequency gain; do not conclude /m/ is inaudible.
/g/ absent	Present	Absent	Present	Possible mid-frequency audibility or fitting issue, or stimulus-specific variability. Check hearing-aid output in the mid frequencies.
/t/ absent	Present	Present	Absent	Possible high-frequency audibility limit. /t/ carries high-frequency speech cues, so check high-frequency gain and output.
Only /m/ present	Present	Absent	Absent	Better access for low than mid/high frequencies. Consider a frequency-specific fitting limit, but verify acoustically before changing the aid.
Only /g/ present	Absent	Present	Absent	Selective response to the mid-frequency sound. May reflect frequency-specific audibility, or stimulus and recording variability.

Pattern	/m/	/g/	/t/	Possible clinical interpretation
Only /t/ present	Absent	Absent	Present	Apparent selective access to high frequencies. Interpret cautiously; check consistency and repeatability.
All three absent	Absent	Absent	Absent	No cortical response detected. At 55 dB: insufficient audibility, or variability, noise or infant state. Still absent at 65 to 75 dB: much greater concern about aided audibility.

These interpretations apply when the pattern is the same at 55, 65 and 75 dB SPL. A single absent sound is a reason to check the fitting in that frequency region, not proof that the sound is inaudible. Selective or absent responses can reflect recording variability as well as audibility: confirm before changing the fitting, by repeating the tests.

Missing /t/ Responses Flag a High-Frequency Gap

Speech consonants are broadband, transient signals, not pure tones: /m/, /g/ and /t/ sample low-, mid- and high-frequency regions of the speech spectrum rather than single peak frequencies. When /t/ is absent, ask whether high-frequency speech is audible through the aid by assessing:

- Hearing-aid output.
- Real-ear / electroacoustic verification.
- Estimated thresholds.
- Earmould acoustics.
- Frequency response.
- Compression.
- Feedback management.
- Frequency lowering.
- Recording reliability.

Repeat Testing Raises Detection

CAEP detection in aided infants when the stimulus was audible (0 dB SL or greater) rose after repeat testing: from 70% to 84% for the mid-frequency stimulus and from 54% to 72% for the high-frequency stimulus. A second test recovered about 40 to 50% of the audible sounds missed on the first test. High-frequency responses were the hardest to detect, so an absent high-frequency result is the one most worth repeating. Repeat before you change the fitting.

Each Level Answers a Different Clinical Question

Level	Speech type	Clinical question
55 dB SPL	Soft speech	Is relatively soft speech reaching the cortex?
65 dB SPL	Conversational speech	Is conversational-level speech reaching the cortex?

Level	Speech type	Clinical question
75 dB SPL	Additional level	Can the system give cortical access when more acoustic level is available?

Australian clinical protocol: start at 65 dB SPL, then test at 55 or 75 dB SPL, using /m/, /g/ and /t/ to check or guide the hearing-aid fitting.

What Matters Most: The Change from 55 to 75 dB SPL

The table shows the result for one sound across the three levels. Inconsistent patterns need repeat testing.

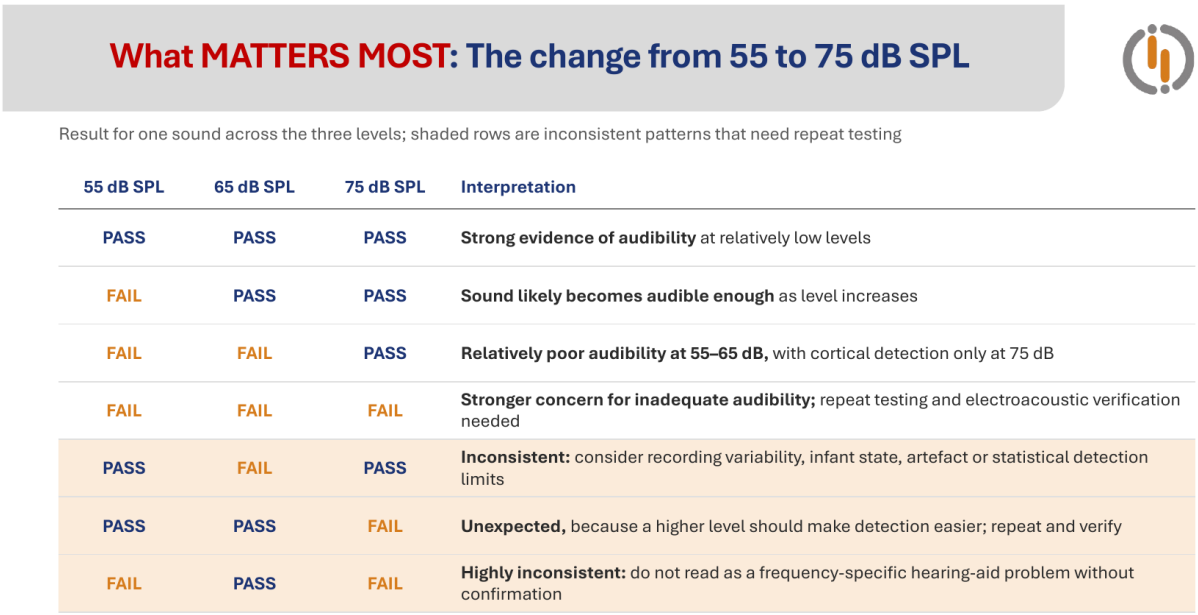


Figure 7. Result patterns for one sound across 55, 65 and 75 dB SPL.

Case Examples

Case A	55 dB SPL	65 dB SPL	75 dB SPL	Observation
/m/	FAIL	PASS	PASS	/m/ and /g/ first appear at 65 dB SPL.
/g/	FAIL	PASS	PASS	/t/ appears only at 75 dB SPL, the highest presentation level.
/t/	FAIL	FAIL	PASS	Next step: check whether the aided fitting gives enough high-frequency audibility.

Interpretation: the pattern suggests adequate cortical access to low- and mid-frequency speech information at conversational levels, but reduced access to high-frequency speech information at 65 dB SPL. High-frequency aided audibility should be verified objectively before modifying the hearing-aid fitting.

Case B	55 dB SPL	65 dB SPL	75 dB SPL	Observation
/m/	PASS	PASS	PASS	/m/ and /g/ present at every level, from 55 dB SPL.
/g/	PASS	PASS	PASS	/t/ absent at every level, even at 75 dB SPL.
/t/	FAIL	FAIL	FAIL	Next step: confirm with hearing-aid verification and, ideally, a repeat CAEP test.

Interpretation: strong aided cortical access to low- and mid-frequency speech information, but persistent absence of the /t/ response raises concern about high-frequency aided audibility. The finding should be confirmed with recording-quality assessment and objective hearing-aid verification before modifying the fitting.

Case C	55 dB SPL	65 dB SPL	Interpretation
/m/	FAIL	PASS	Emerges at the higher level: /m/ becomes sufficiently audible as level increases.
/g/	FAIL	PASS	Same pattern as /m/, suggesting level-dependent audibility.
/t/	FAIL	FAIL	No response at either level. Greater concern about access to the acoustic information in /t/, though this alone does not prove inaudibility.
/s/	Not tested	Not tested	No result. Not tested, or no interpretable measurement was obtained.

Interpretation: partial cortical access to amplified speech. /m/ and /g/ become cortically detectable at 65 dB SPL, whereas /t/ remains undetected. The pattern warrants particular attention to high-frequency aided audibility and should be confirmed with hearing-aid verification and/or repeat ACA.

Q2 **Quiz Hint:** /m/, /g/ and /t/ sample the low-, mid- and high-frequency regions of the speech spectrum. These speech consonants are broadband, transient signals rather than pure tones, so together they show whether speech energy from each region produces a cortical response.

Conclusion

- A present CAEP is reassurance that speech is audible with the current fitting.
- An absent CAEP does not always mean inaudible: up to 23% were absent in audible infants, so cross-check sounds, levels, visits and PEACH.
- The protocol is workable: two levels, three sounds, within 8 weeks of fitting and one appointment.
- Four key areas of use: fitting evaluation, unaided audibility in ANSD, CI candidacy, and parent counselling (after the PEACH questionnaire).
- Know the limits: ACA is not for thresholds, discrimination or unguided CI testing.

Interactive Worksheet

Complete this worksheet during or after the course. Click any gray response box to type your answer. Checkboxes are best completed in desktop Word.

Module 1: Why Objective Evaluation Is Needed and What ACA Measures

Key terms and guided notes

Key term	Definition in your own words
CAEP	
Free field	
ANSD	
VRA	
PEACH	

The three speech sounds used in the Australian ACA protocol, and the frequency region each samples, are:

Low-frequency sound	Mid-frequency sound	High-frequency sound

Explain what ACA shows about an infant's response to amplified speech, and what it does not show:

Pause and Apply: If I am fitting hearing aids for an infant who is too young for behavioral testing, then I will use ACA to:

Module 2: Recording Setup and How a CAEP Is Detected

Sequencing activity

Number these steps in the order the ACA system performs them, 1 through 5.

Step number	Step
	Statistical test compares the response with residual background activity
	Artifacts from movement and muscle activity are rejected
	Speech stimulus (/m/, /g/ or /t/) is presented in the free field
	PASS or FAIL is reported
	EEG is recorded from scalp electrodes

Quick check: select True or False.

A statistically significant CAEP means the infant has a normal audiogram.

☐ True ☐ False

Sensation level is approximately the presentation level minus the aided threshold.

☐ True ☐ False

The critical parameter in the recording setup is the stimulus intensity at the test ear.

☐ True ☐ False

Pause and Apply: If a clinician asks how to set up an ACA recording, then I will explain:

Module 3: The Evidence and Where ACA Fits in the Toolbox

Window pane summary

What ACA measures	**What ACA does not measure**
Why an absent CAEP is not proof of inaudibility	**What ACA adds beyond ABR and ASSR**

Matching: write the letter of the matching definition or outcome in the box next to each term.

Letter	Term or scenario	Definition or outcome
	1. Electroacoustic verification	A. Recording too noisy to decide; says nothing about audibility
	2. Aided cortical assessment	B. Behavioural response to the stimulus
	3. VRA	C. A statistically detectable response in a valid recording
	4. PASS result	D. Hearing-aid output under specified acoustic conditions
	5. Inconclusive result	E. Statistical detection of the amplified speech stimulus at the cortex

Pause and Apply: If an infant has a present CAEP but cannot yet perform VRA, then I will tell the family:

Module 4: Interpreting ACA Result Patterns

Unfolding case

Part 1. An infant has been fitted with hearing aids and cannot yet perform VRA. Which steps in the pathway after fitting would you follow, and when?

Part 2. Aided CAEP testing at 55, 65 and 75 dB SPL shows /m/ and /g/ present at every level and /t/ absent at every level. What does this pattern suggest?

Part 3. What should you check or do before modifying the hearing-aid fitting?

Part 4. After adjustment, CAEPs remain absent across sounds, levels and visits. What is your next step?

Clinical Reference Tool: Absent CAEP Checklist

Step	My notes on this child or case
☐ Check the 75 dB SPL speech-o-gram	
☐ Use the PEACH to see whether the child responds to sound in daily life	
☐ Rule out simple causes: middle ear disease, arousal, noise	
☐ Consider CI referral if absence is consistent across sounds, levels and visits	

This tool is for clinical reference only. Always follow your facility's protocols.

Pause and Apply: If /t/ is absent at all three levels, then I will:

Post-Course Reflection

What was the most significant thing you learned that surprised you or challenged your existing practice?

What knowledge gaps did this course reveal in your own skills or knowledge?

Describe a specific patient or client from your own practice where you would apply something from this course:

What is one thing you will do differently in your practice next week as a result of this course?

Action Plan

Identify at least 2 specific, measurable changes you plan to make to your clinical practice as a direct result of this course. Use the If-Then format where possible: "If I encounter [situation X], then I will [action Y]." This is more useful than "I will improve my practice."

My action plan goal	Target date	How I will measure success

Notes

Quiz Summary

The following quiz hints appeared throughout the course content. Use this section as a quick study reference.

Q1	**Quiz Hint:** Aided CAEPs are most informative when behavioral responses cannot be obtained. They show whether amplified speech is reaching the auditory cortex in infants too young for VRA and in children with ANSD, where ABR cannot estimate thresholds.
Q2	**Quiz Hint:** /m/, /g/ and /t/ sample the low-, mid- and high-frequency regions of the speech spectrum. These speech consonants are broadband, transient signals rather than pure tones, so together they show whether speech energy from each region produces a cortical response.
Q3	**Quiz Hint:** A statistically significant CAEP means the EEG response is distinguishable from background noise, so the stimulus produced detectable activity at the auditory cortex under the test conditions. It does not mean normal hearing, a normal audiogram, normal speech perception, or normal language development.
Q4	**Quiz Hint:** An absent CAEP warrants further investigation of stimulus audibility, hearing-aid fitting and recording conditions before clinical conclusions are drawn. Noise, infant state and other technical factors can cause an absent result, so cross-check before changing the fitting.
Q5	**Quiz Hint:** ACA occupies the gap between hearing-aid fitting and reliable behavioral assessment. It is a complementary physiological measure that shows whether amplified speech is activating the cortex while behavioral information is limited, and it does not replace electroacoustic verification.

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Additional Information

Presenter Bio

Prof. Stavros Hatzopoulos is a faculty member of the Audiology & ENT clinic, University of Ferrara, Italy, since 1994. His background is in Biomedical engineering and Hearing Science (BS, from University of Southern California, MSc from Texas A&M, PhD from Worcester Polytechnic Institute in Massachusetts). He received his habilitation as an associate professor in 2014. He is the author of more than 245 book chapters, peer review papers and congress presentations. He has participated in numerous European Concerted Action projects in the areas of Otoacoustic Emissions, Genetics and Nanotechnologies. His main interests are clinical Auditory Electrophysiology, Teleaudiology and Long Distance Learning. Currently serves as the editor of the Portal on Otoacoustic Emissions (www.otoemissions.org) and as Managing Editor of the Hearing, Balance & Communication journal.

Presenter Disclosure

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Additional Information (continued)

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