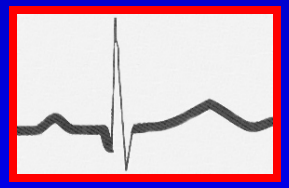
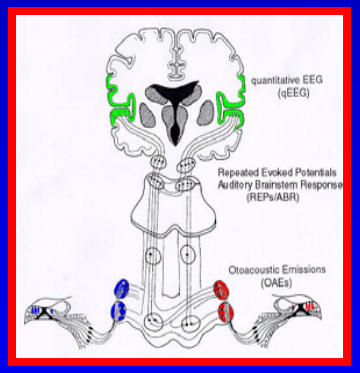
NEUROCARDIOLOGY: Noninvasive functional assessment using the AXS Test Battery

Judith L. Lauter PhD





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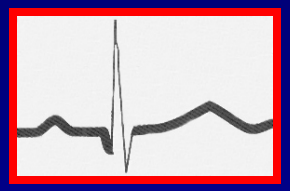
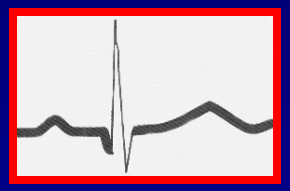


Neurocardiology:
Noninvasive functional assessment using the AXS Test Battery

I. Background, goals, and focus

II. Test battery: logic and procedures

III. Results: correlated functions

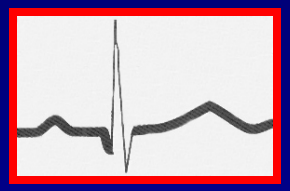


Background, goals, and focus

1. The cardiovascular system is innervated in a complementary fashion through the action of the two subdivisions of the Autonomic Nervous System (ANS) -- the Sympathetic and the Parasympathetic Nervous Systems (SNS & PSNS).

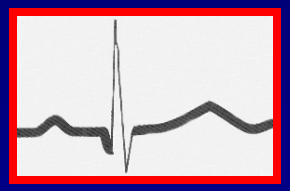
2. Both the SNS and PSNS have peripheral components, but the PSNS is also known to have central control elements, at least at the brainstem level.

3. However, little is known about exactly how central PSNS control interacts with peripheral SNS function to manage cardiovascular homeostasis, or the way in which this affects individual differences, such as “elevated sympathetic tone,” a risk factor for cardiac problems.



4. The “cold pressor” test (placing one hand in ice water) has been used for many years to activate the SNS, resulting in dramatic cardiovascular effects such as increased heart rate and blood pressure.

5. Three preliminary studies were conducted using components of the AXS Test Battery as an indirect means of studying peripheral and central physiology associated with cold pressor as an SNS challenge.



Dependent-variable sets for the three studies:

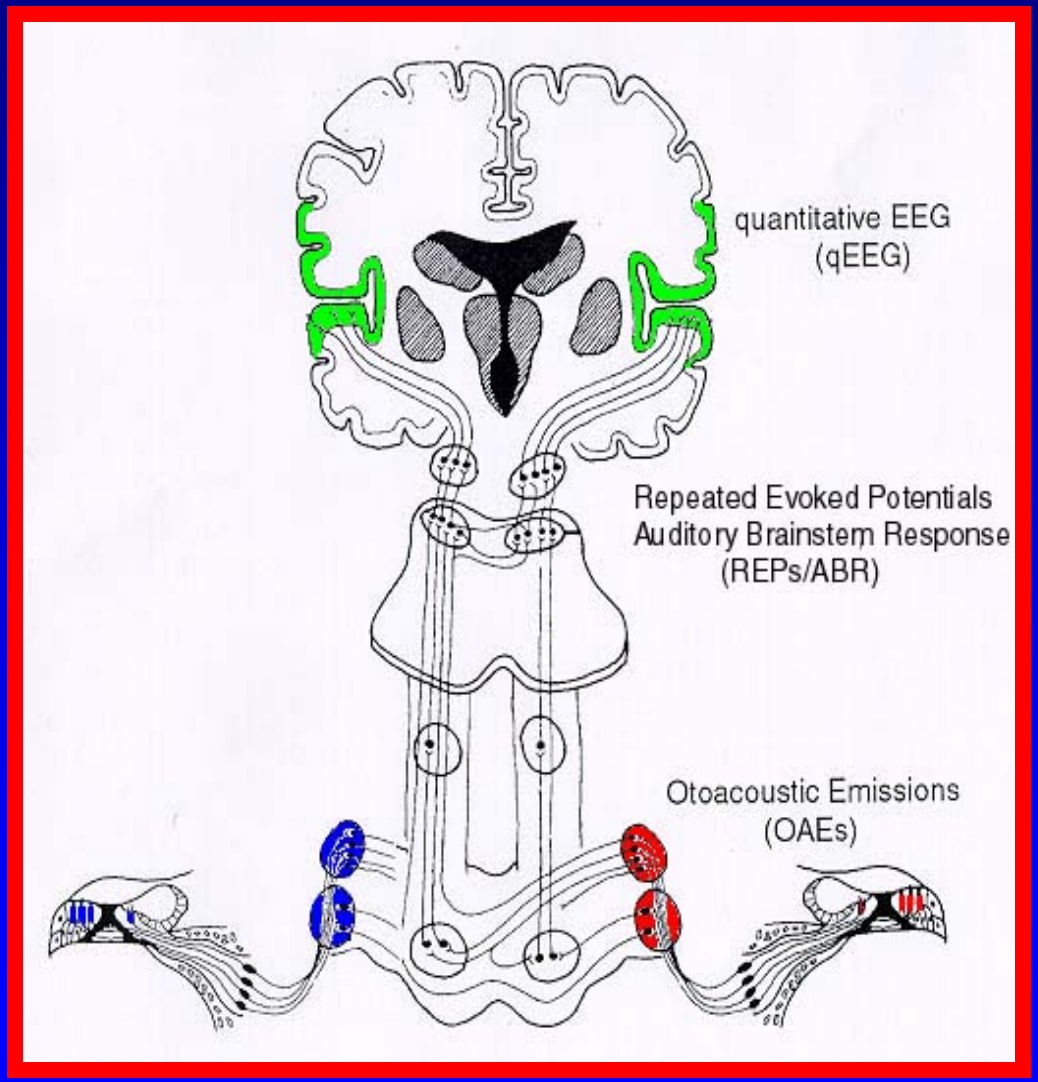
Study #1 -- Heart rate [HR], systolic blood pressure [sBP], diastolic BP (dBP)

Study #2 -- HR, sBP, dBP, otoacoustic emissions [OAEs], speech acoustics (temporal phonetic cue created by larynx: "Voice Onset Time" for the phoneme /k/)

Study #3 -- HR, sBP, dBP, OAEs, cortical qEEG

Auditory Cross-Section (AXS) Battery

"access to axes"

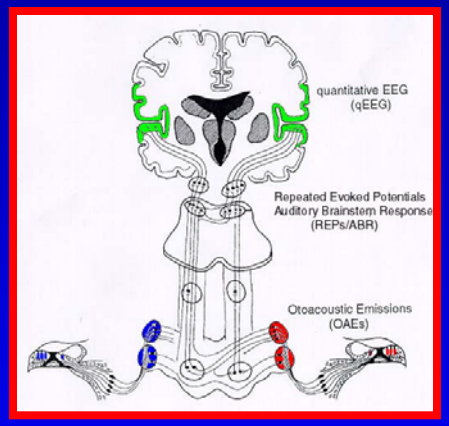


Lauter (1997)

AXS BATTERY – PROCEDURES

1. Behavioral background (audiometry, medical history, etc.)

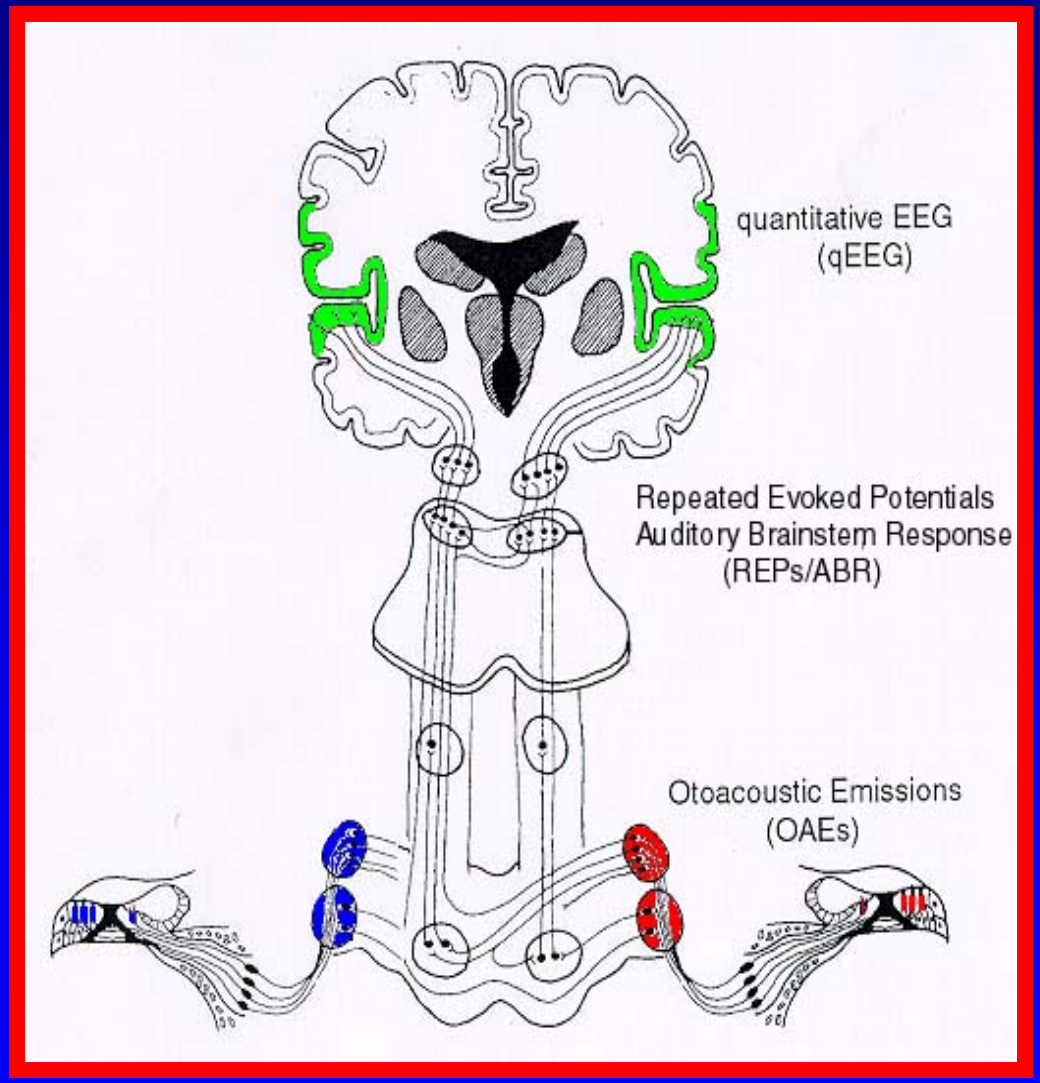
2. Three-level physiological profile
   A. Otoacoustic emissions (OAEs)
   B. Repeated Evoked Potentials
      Auditory Brainstem Response (REPs/ABR)
   C. quantitative Electroencephalography (qEEG)



3. Complementary tests for more information
   (eye movements, speech acoustics, laryngeal motor control, cardiac function, behavioral tests, brain imaging, etc.)

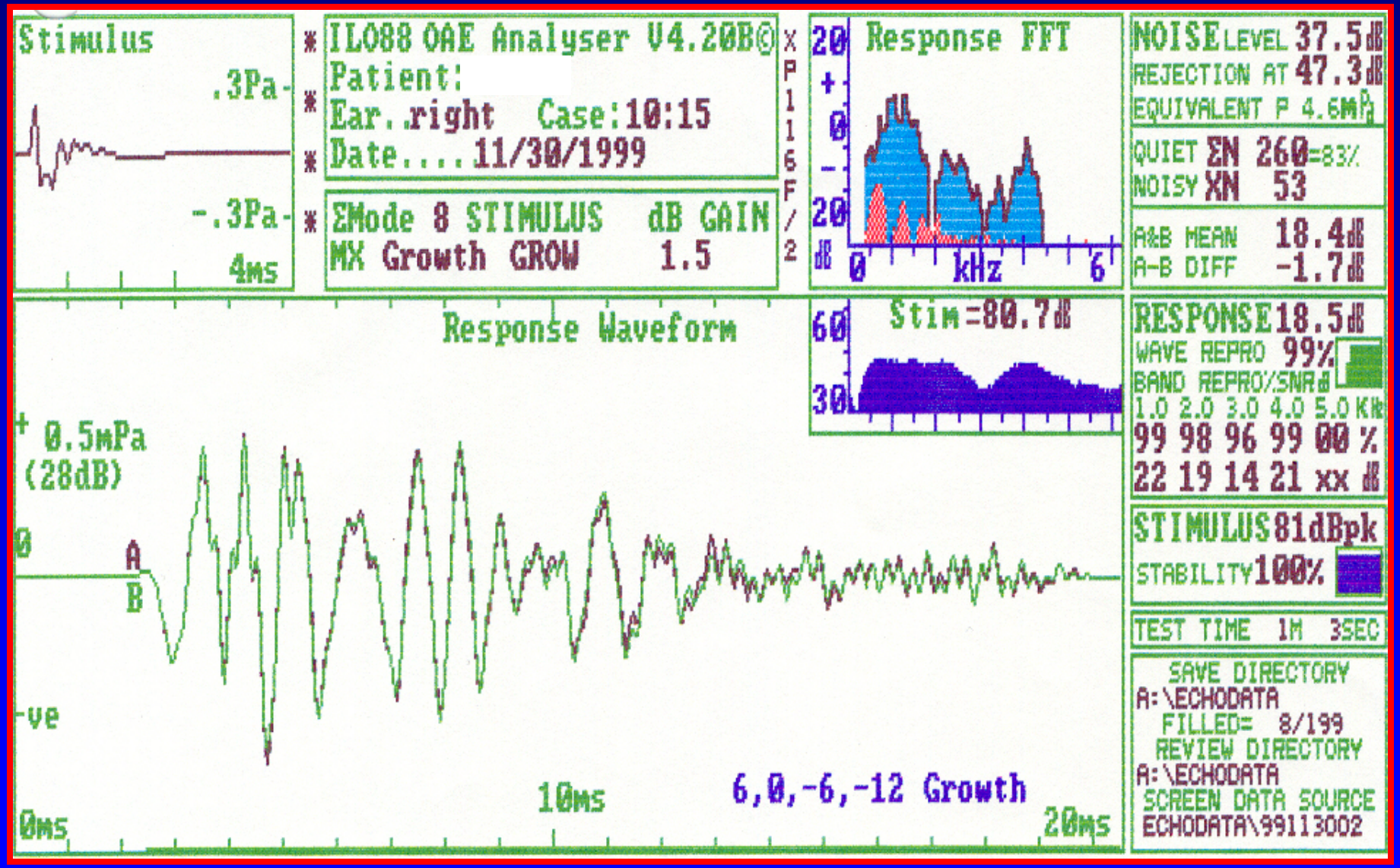
Auditory Cross-Section (AXS) Battery

"access to axes"



Lauter (1997)

Transient-Evoked Otoacoustic Emissions (TEOAEs)



ILO 92

AXSBattery

Otoacoustic Emissions (OAEs)

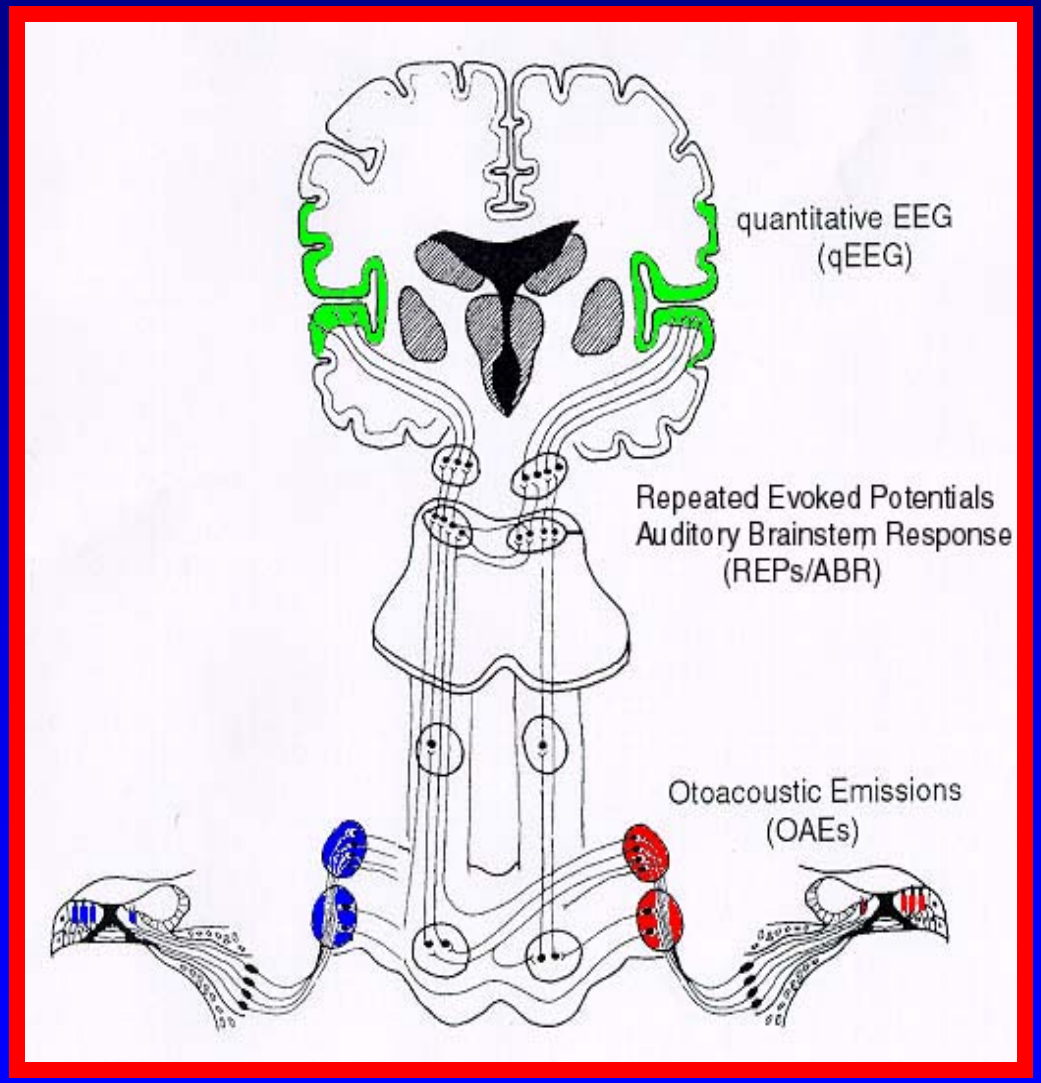
- Otodynamics ILO system: “quick TEOAE” routine

- dependent variables:
  - “average response amplitude” and “A-B difference” over 3 runs in R ear
  - “average response amplitude” and “A-B difference” over 3 runs in L ear

Lauter 1997

Auditory Cross-Section (AXS) Battery

"access to axes"



Lauter (1997)

Auditory Cross-Section (AXS) Battery

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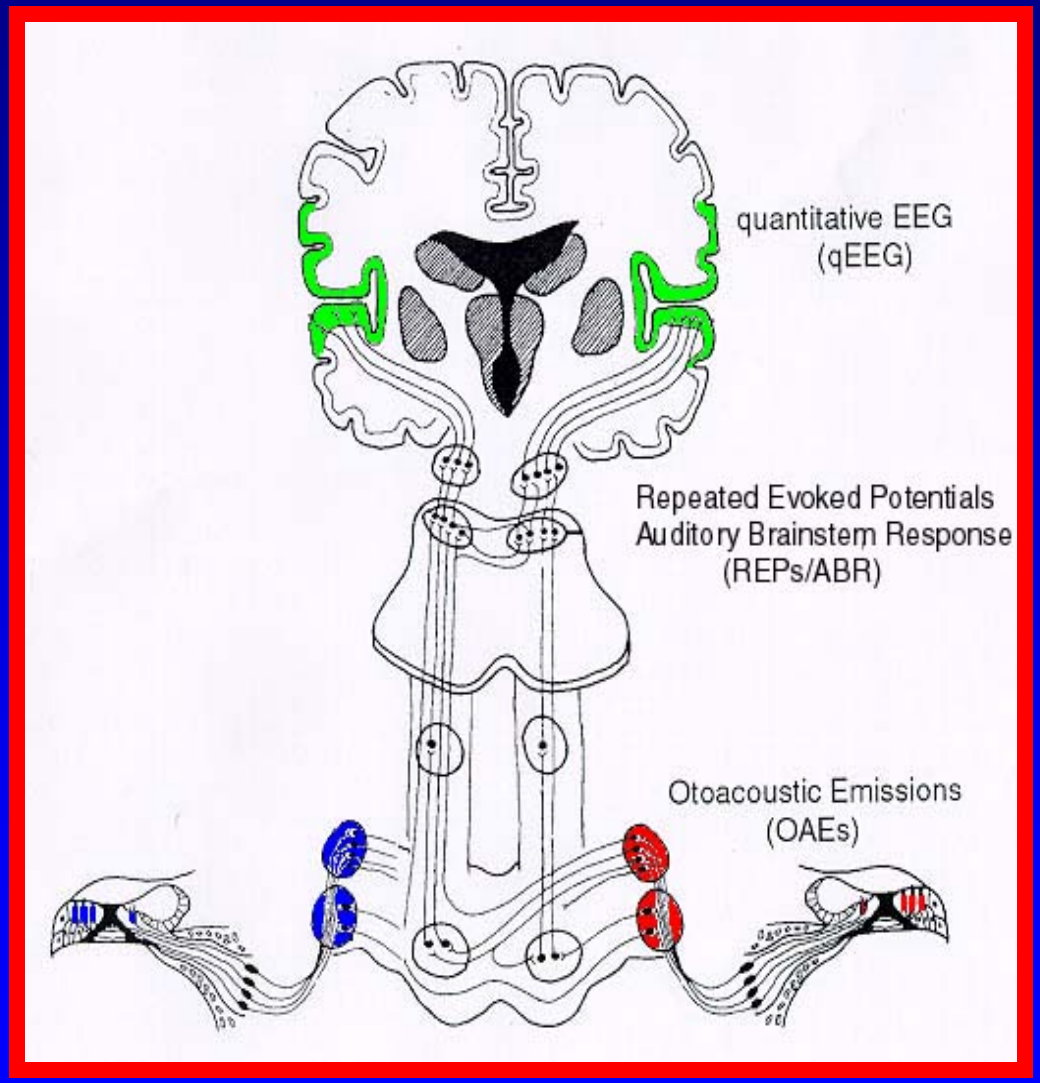
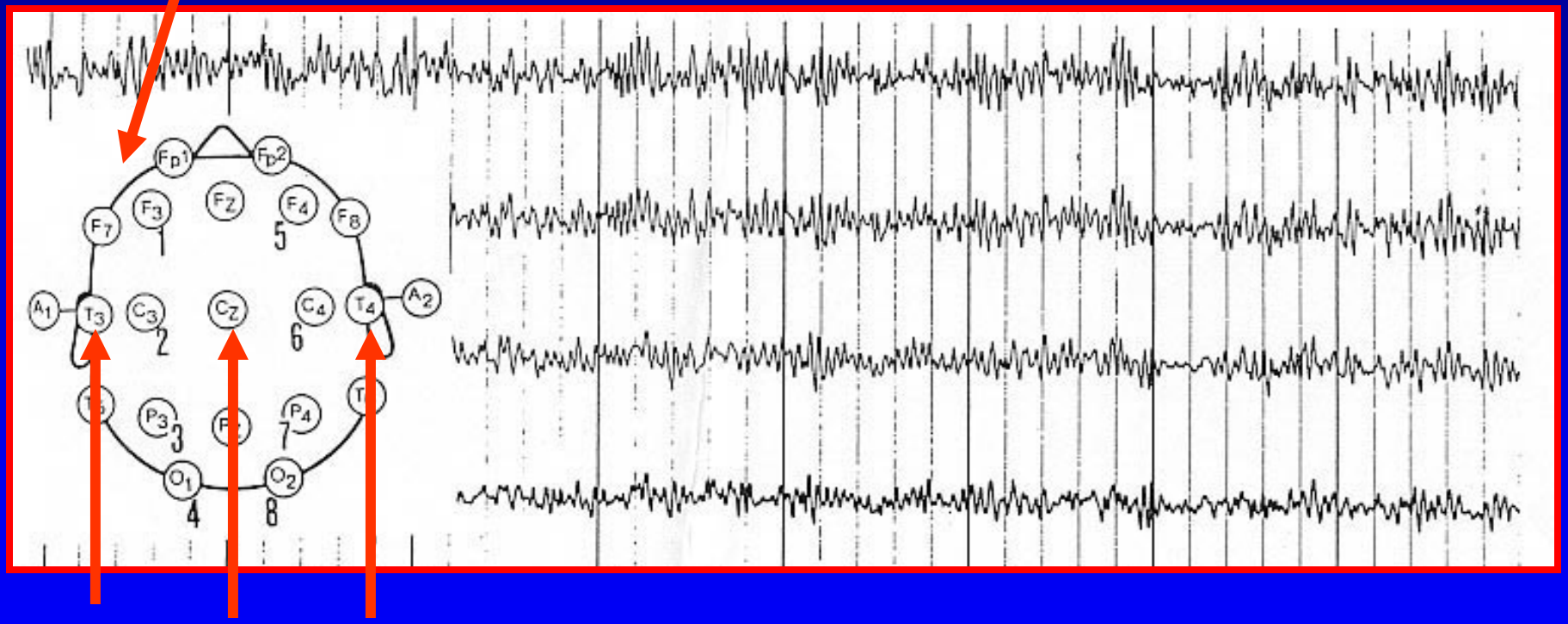


Lauter (1997)

AXS Battery qEEG – 4 active electrodes

left eyebrow = eye movements



T3 Cz T4

\+ forehead (ground)
2 earlobes (reference)
TOTAL = 7

AXSBattery

quantitative electroencephalography (qEEG)

- standard parameters, 4-channel recording
  (eyebrow, vertex, T3, T4)

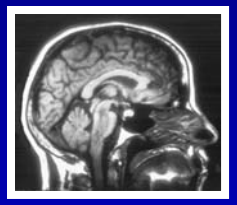
- 5.5 min of resting EEG
  (eyes closed, room darkened)

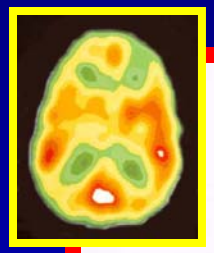
- dependent variables:
  - power per site in each of 4 bands
  - coherence per pair in each of 4 bands
  - T3/4 asymmetries (beta, total)

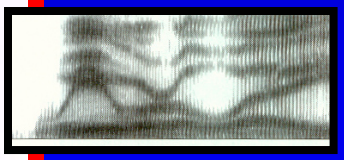
Lauter 1997

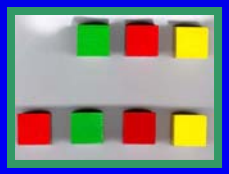
Auditory Cross-Section (AXS) Battery

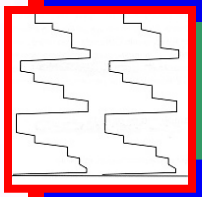
"access to axes"

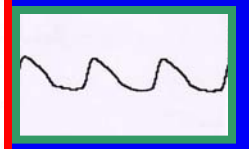


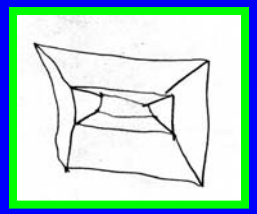


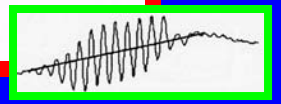












Lauter (1997)

AXSBattery

Heart rate and blood pressure

-Marshall self-inflating cuff

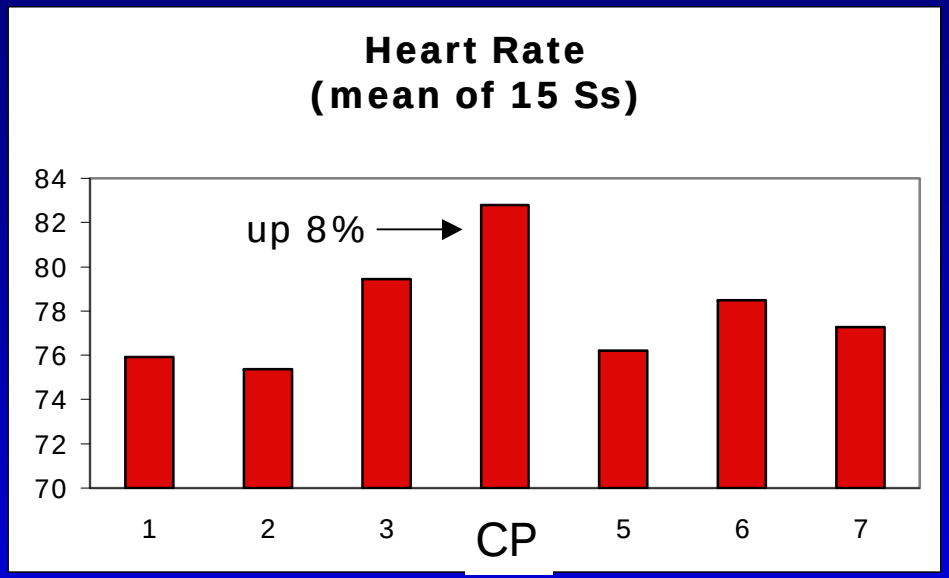
-1-min recordings

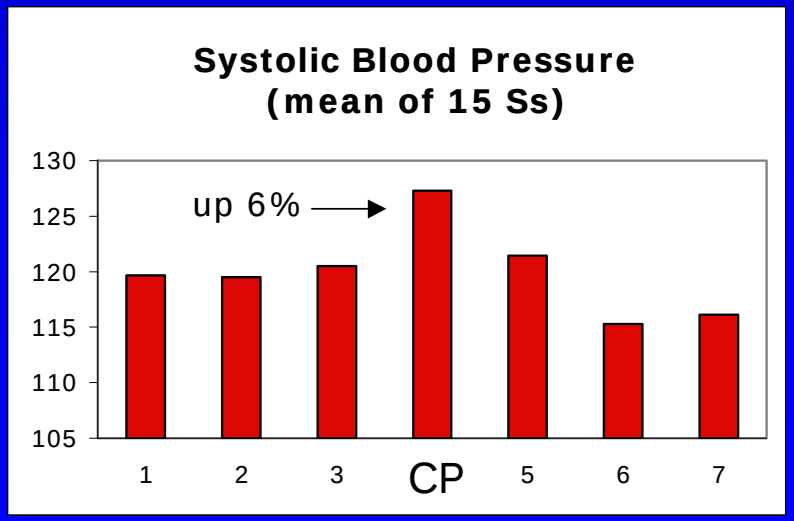
-Dependent variables

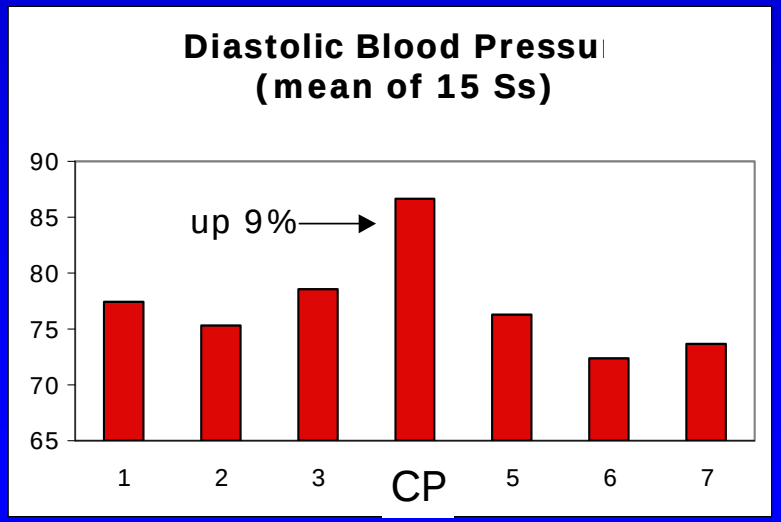
- systolic blood pressure (sBP)
- diastolic blood pressure (dBP)
- heart rate (HR)

1. Changes in heart measures with cold pressor challenge

(n = 15)







2. Correlated changes in heart, inner ear (OAEs), and voice (VOT of /k/) with cold pressor challenge

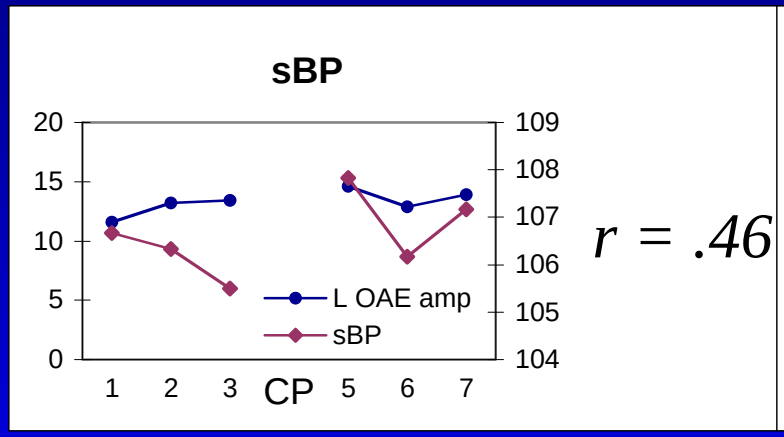
(n = 4)

Correlations (group data):

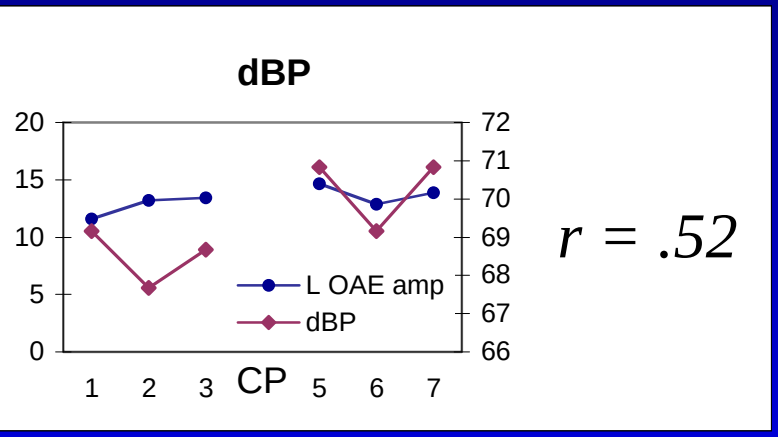
	sBP	dBP	HR
L-ear OAE amplitude	.45	.52	-.71
R-ear OAE amplitude	-.31	-.00	.33
VOT of /k/	.82	.82	-.65

2. Correlated changes in heart, inner ear (OAEs), and voice (VOT of /k/) with cold pressor challenge

Left-Ear OAE (dB SPL)

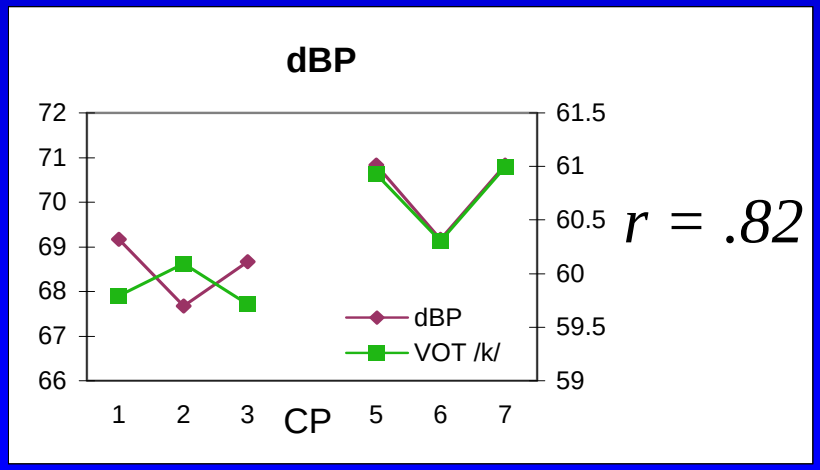


$r = .46$



$r = .52$

VOT /k/ (msec)

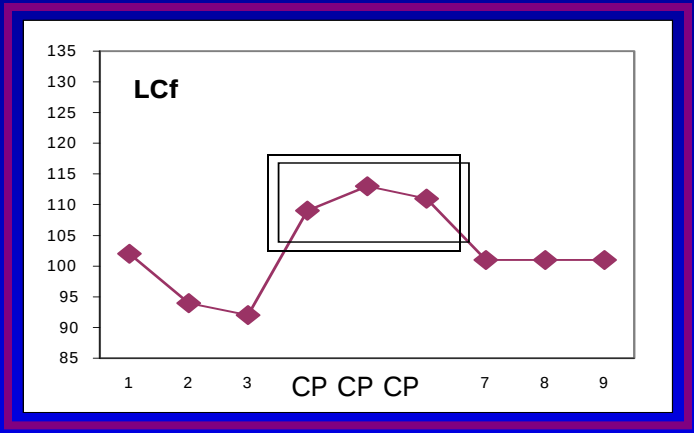


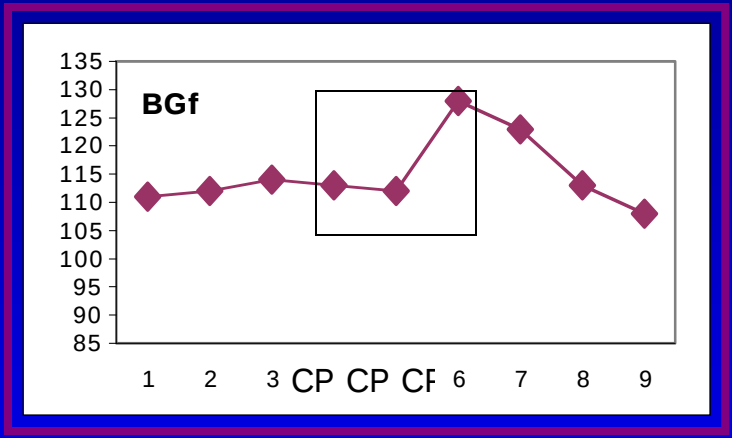
$r = .82$

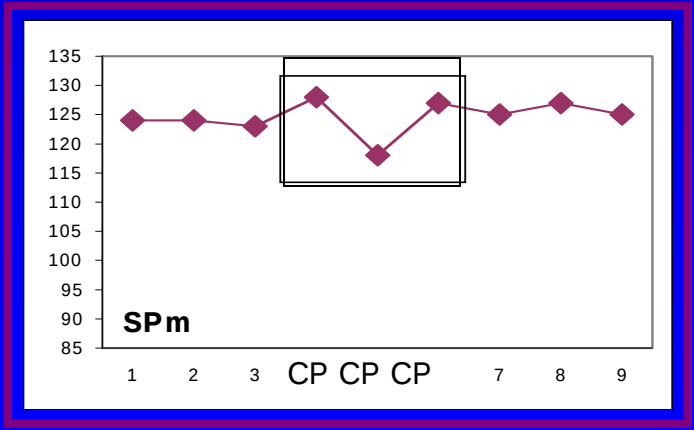
3. Correlated changes in heart, ear, and cortex with cold pressor challenge

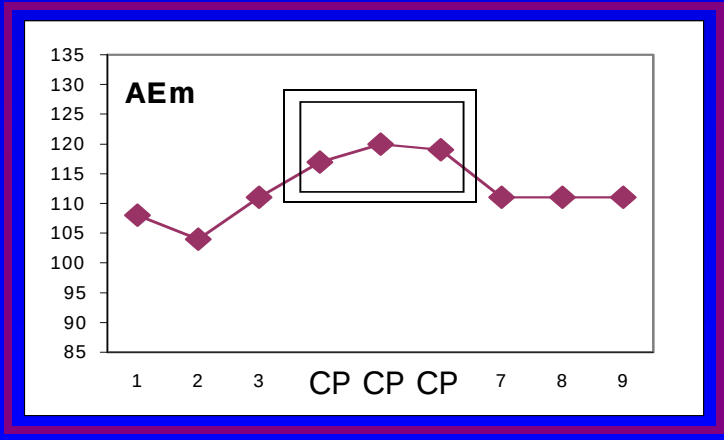
n = 4

a. Example of changes in heart measure (systolic BP)



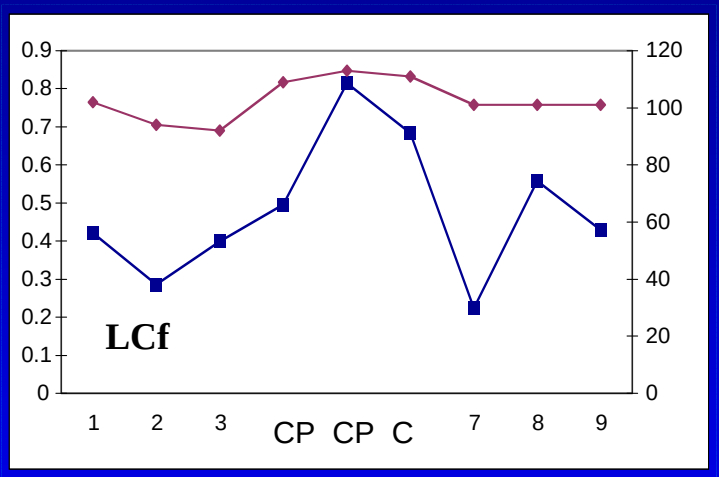


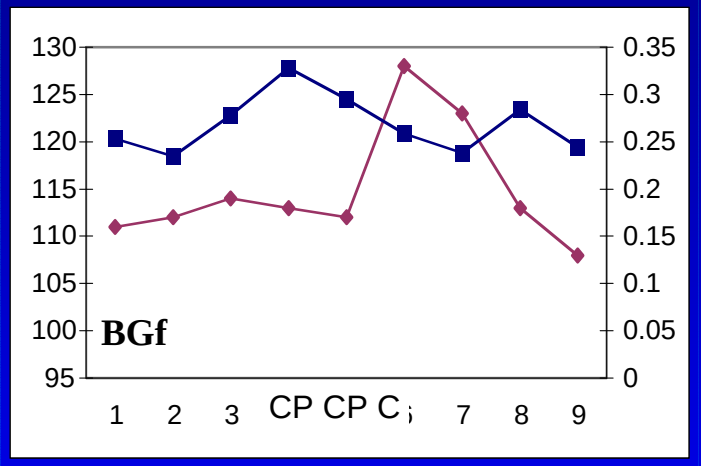


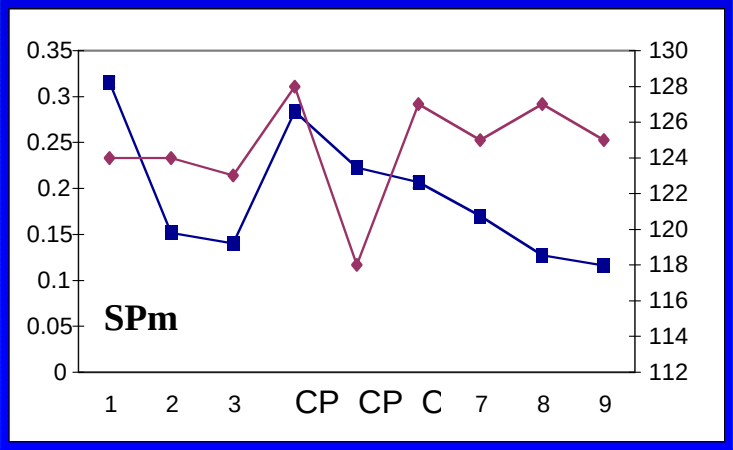


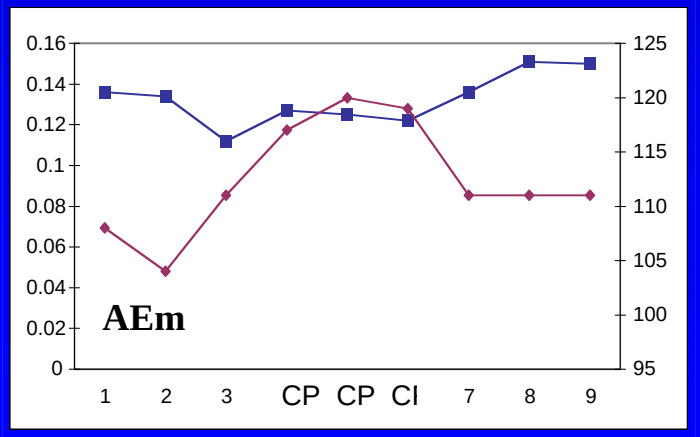
3. Correlated changes in heart, ear, and cortex with cold pressor challenge

b. Systolic BP x cortical change (Right-side beta power)



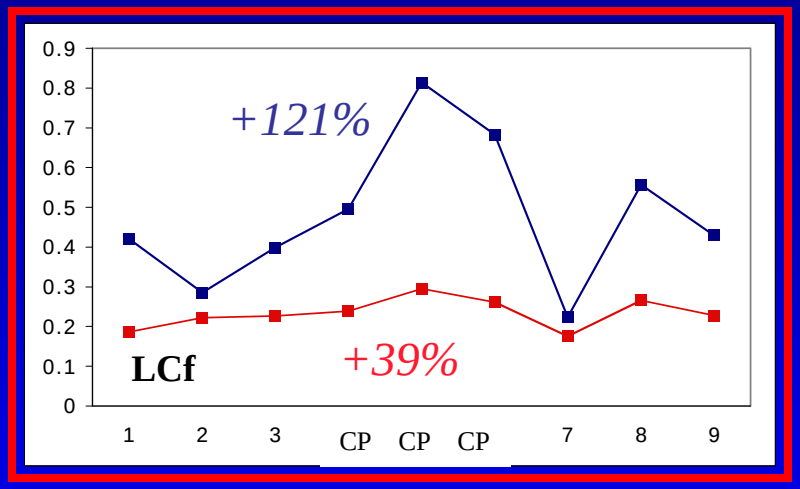


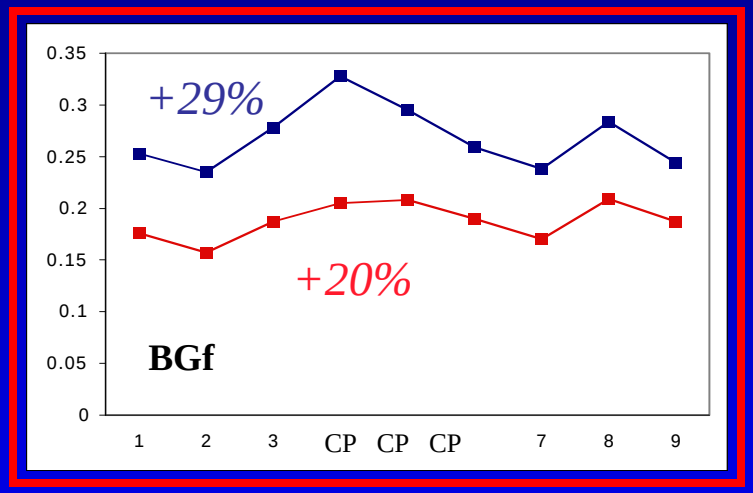


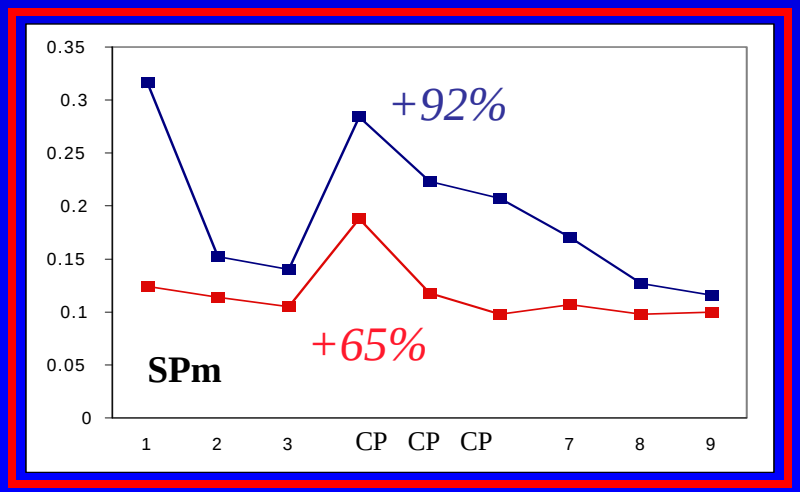


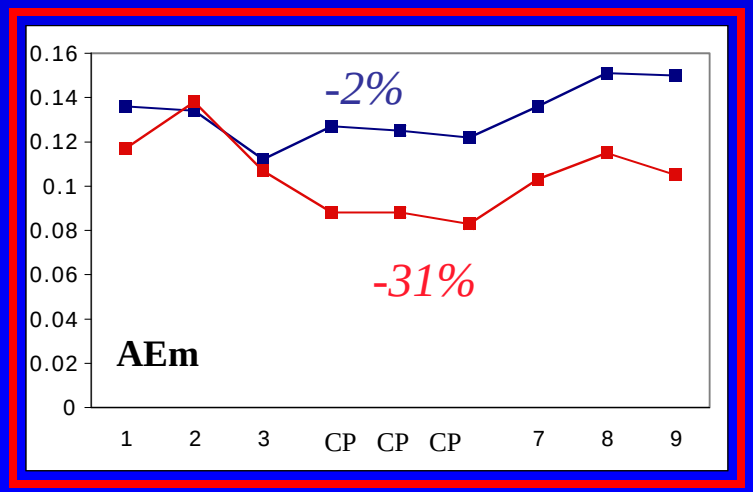
3. Correlated changes in heart, ear, and cortex with cold pressor challenge

c. Bilateral cortical change (R- vs. L-side beta power)

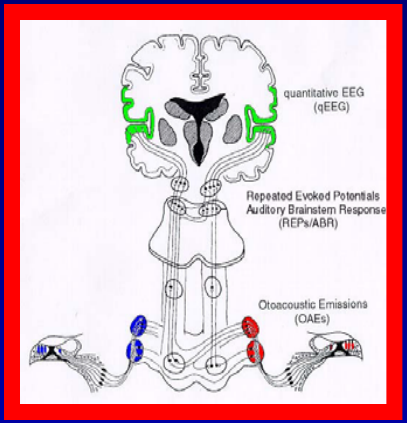








PROMISE OF AXS BATTERY FOR HUMAN NEUROSCIENCE



1. "Fingerprint" neural profile for each individual

2. Details + systems-level characterization

-- specific features related to side and level -- plus information about relations linking sides and levels of the system in a dynamic, "handshaking" way

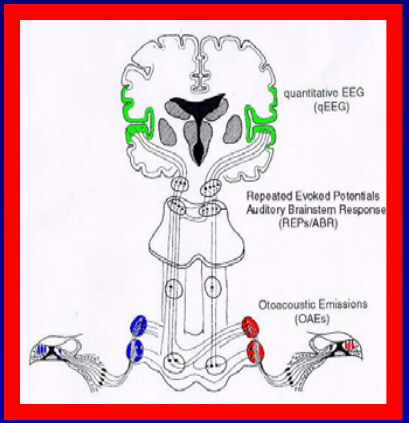
3. Easily related to individual results on any other test

-- whether behavior, anatomy, or physiology
-- spontaneous changes; before/after training, medications
-- source of neural-based design & guidance for rehabilitation

4. Requirements are modest

-- infrastructure, training, personnel
-- particularly compared with other noninvasive approaches for studying the human brain

PROMISE OF AXS BATTERY FOR CENTRAL NEUROCARDIOLOGY -- The Collaboration Potential



1. **New insights into normal function**
   a. co-variation among peripheral measures
   b. co-variation comparing center vs. periphery
   c. individual differences defined in psychology, education, athletic performance, etc. (including pain response)

2. **Clinical populations**
   a. individuals with known cardiac malfunction
   b. “early warning signs” of problems based on disordered central control of the heart and vessels
   c. vascular headache (cluster, migraine, etc.)
   d. chronic pain dysfunction (phantom limb, etc.)