PLASTICITY & ERPS

BRAINS CHANGE WITH EXPERIENCE - NORMAL & ABNORMAL
AND EXPERTISE

- AFTER ABNORMAL INPUT (BLINDNESS, DEAFNESS)
- WITH PRACTICE & LEARNING, EXPERTISE

Nonhuman animal research

- kittens exposed to environment with one type of visual input or none at all
- rats raised in enriched/impoverished environments
- birds deafened to their own songs

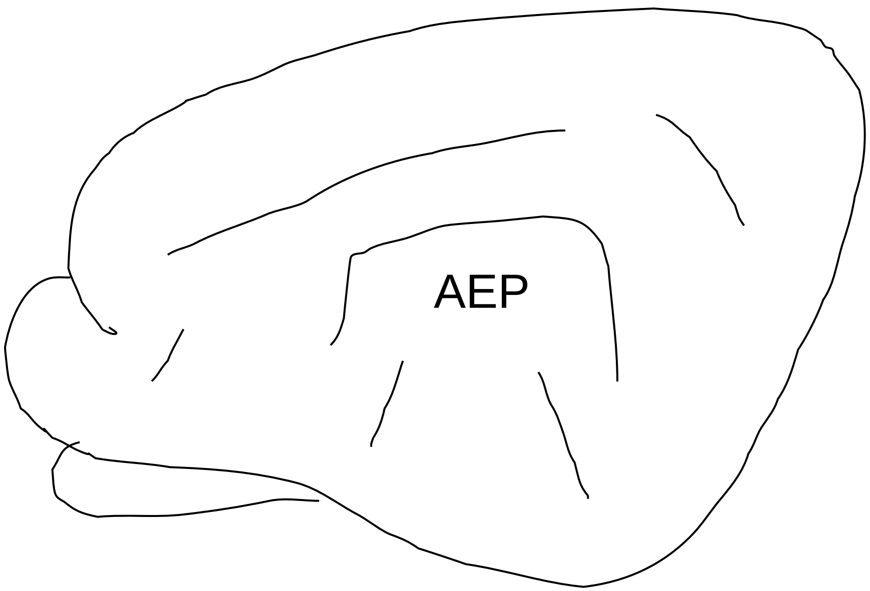
Profound effects of such manipulations on a variety of brain measures including fine structure of the nervous system and the physiology of the cortex.

For a long time, most plasticity research involved non-human animals!

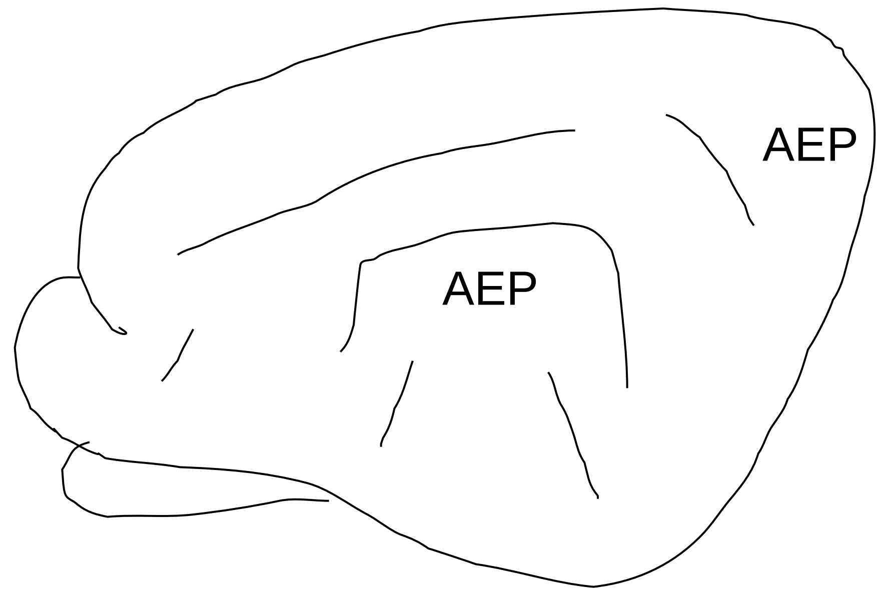
Effects of early experience on brain areas directly associated with altered sensory modality (e.g., decrease in number of binocular cells in the visual cortex after monocular deprivation).

In addition, areas deprived of input (i.e., after unimodal sensory deprivation), also may change so as to respond to other modalities or to function differently in response to other intact modalities (*compensatory neural reorganization*).

Blind mice elicit ERPs to auditory stimuli over visual cortex whereas normally hearing mice do not.



SEEING MICE



BLIND MICE

Inference: a visual area which normally has little to do with processing auditory inputs has reorganized itself to take on some of this function

Deaf cats elicit ERPs to visual stimuli over auditory cortex.

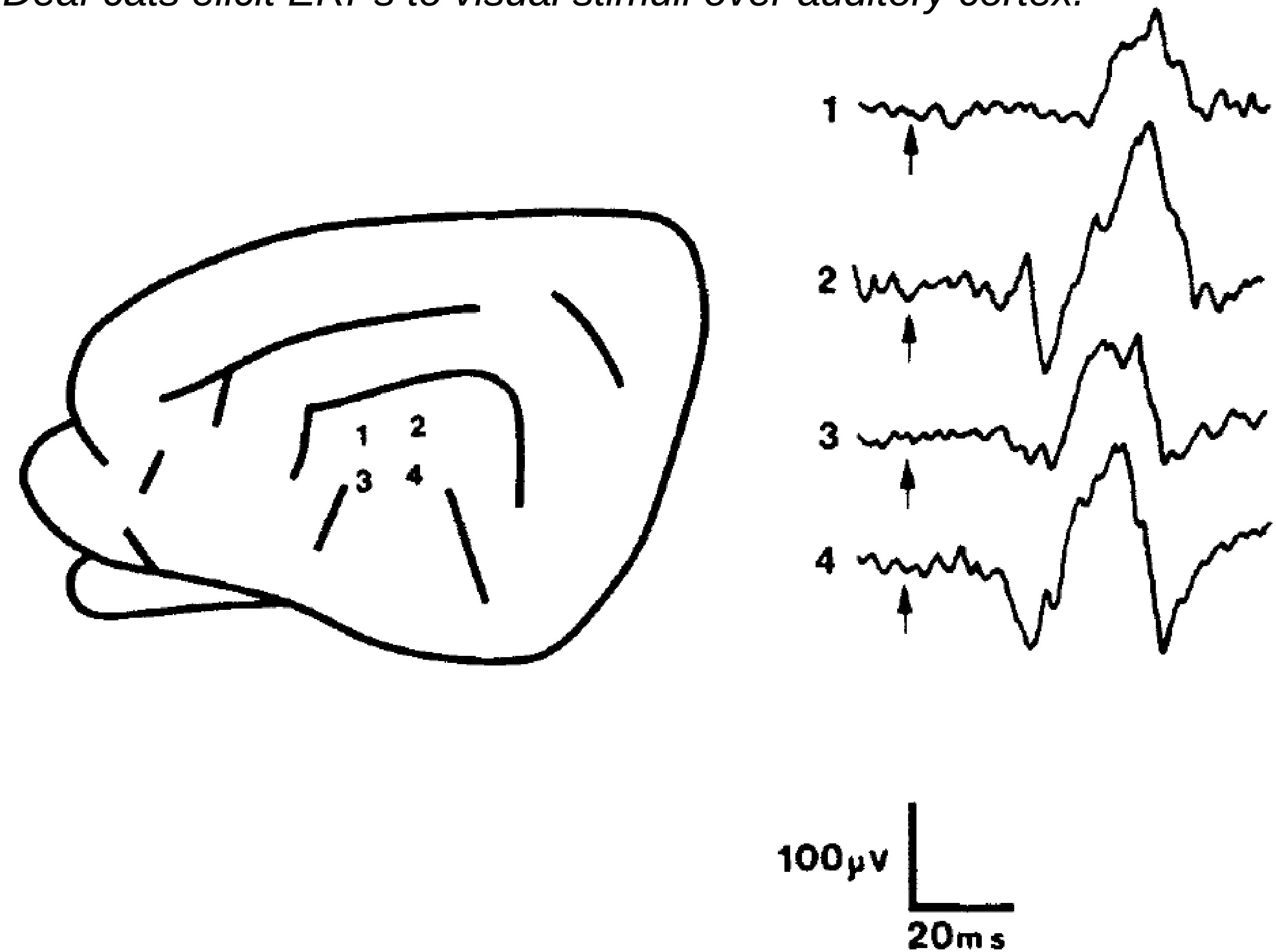
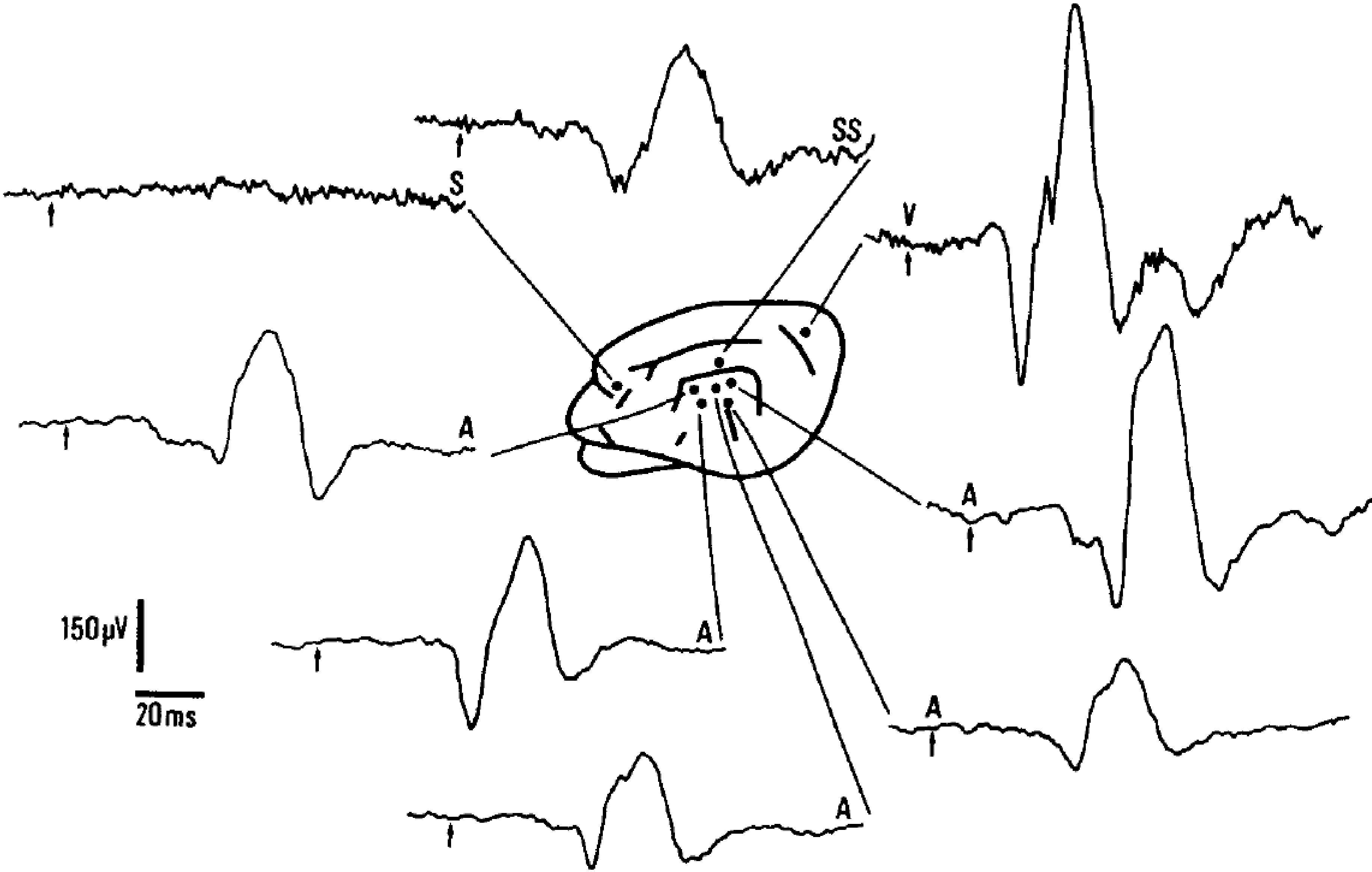


Fig. 1. Examples of visual responses recorded in the primary auditory cortex of an adult cat cochle-ectomized early in development.

Deaf cats show ERPs to visual stimuli over auditory cortex.



Compensatory changes in auditory cortex to visual stimulation following auditory deprivation; areas deprived of normal input can assume other functions (see VEPs in visual area, auditory areas, and even somatosensory area.

Blind mice elicit ERPs to auditory stimuli over visual cortex whereas normally hearing mice do not.

Deaf cats elicit ERPs to visual stimuli over auditory cortex.

Areas deprived of normal input seem to take up other functions.

Open Questions:

- Does this reorganization really have functional consequences
- Can such plasticity also be observed in humans as well?

Rectangle of light flashed
@fovea, LVF, RVF 8 deg

ISI = .5, 1s, 3s

ERPs @ 3s

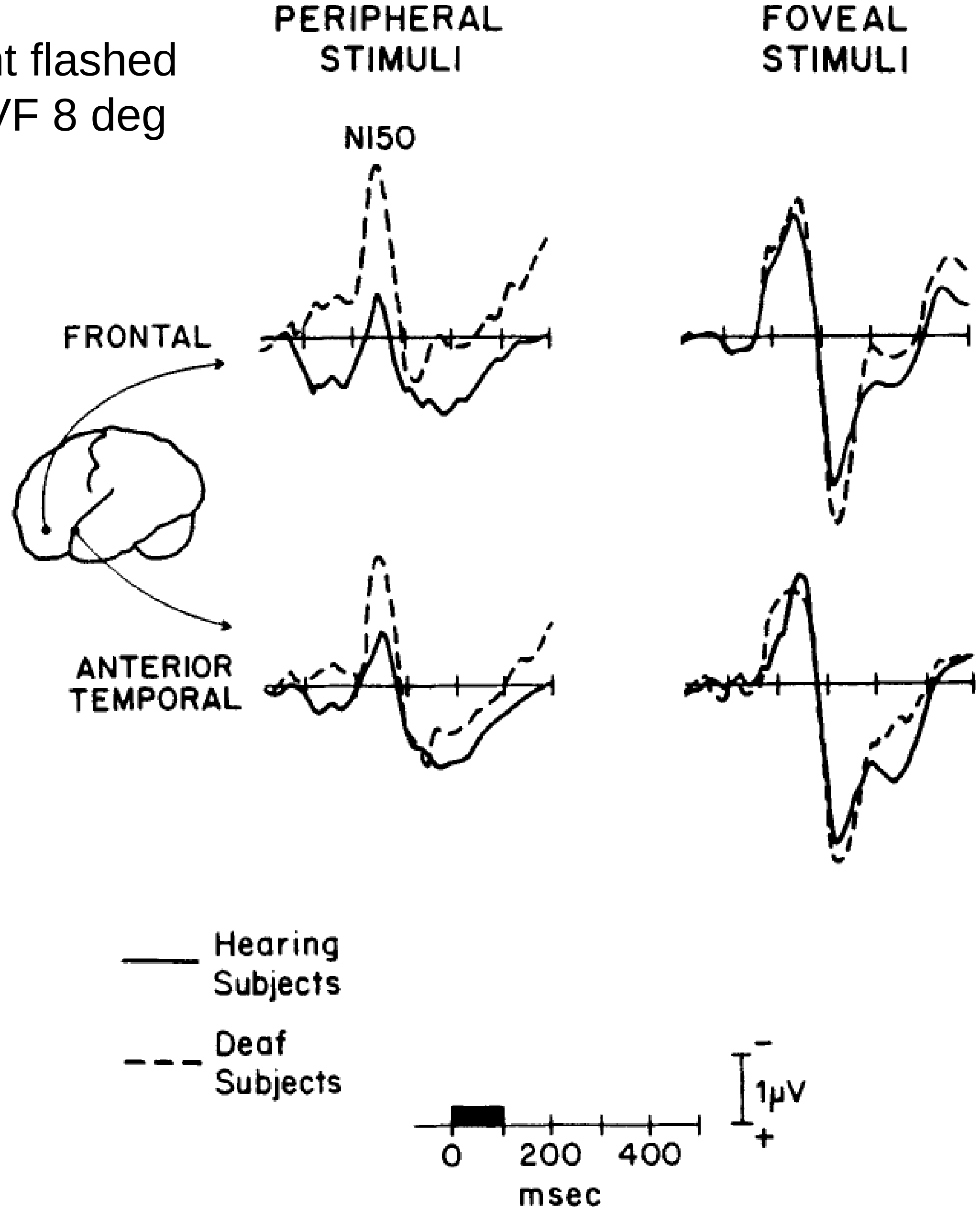
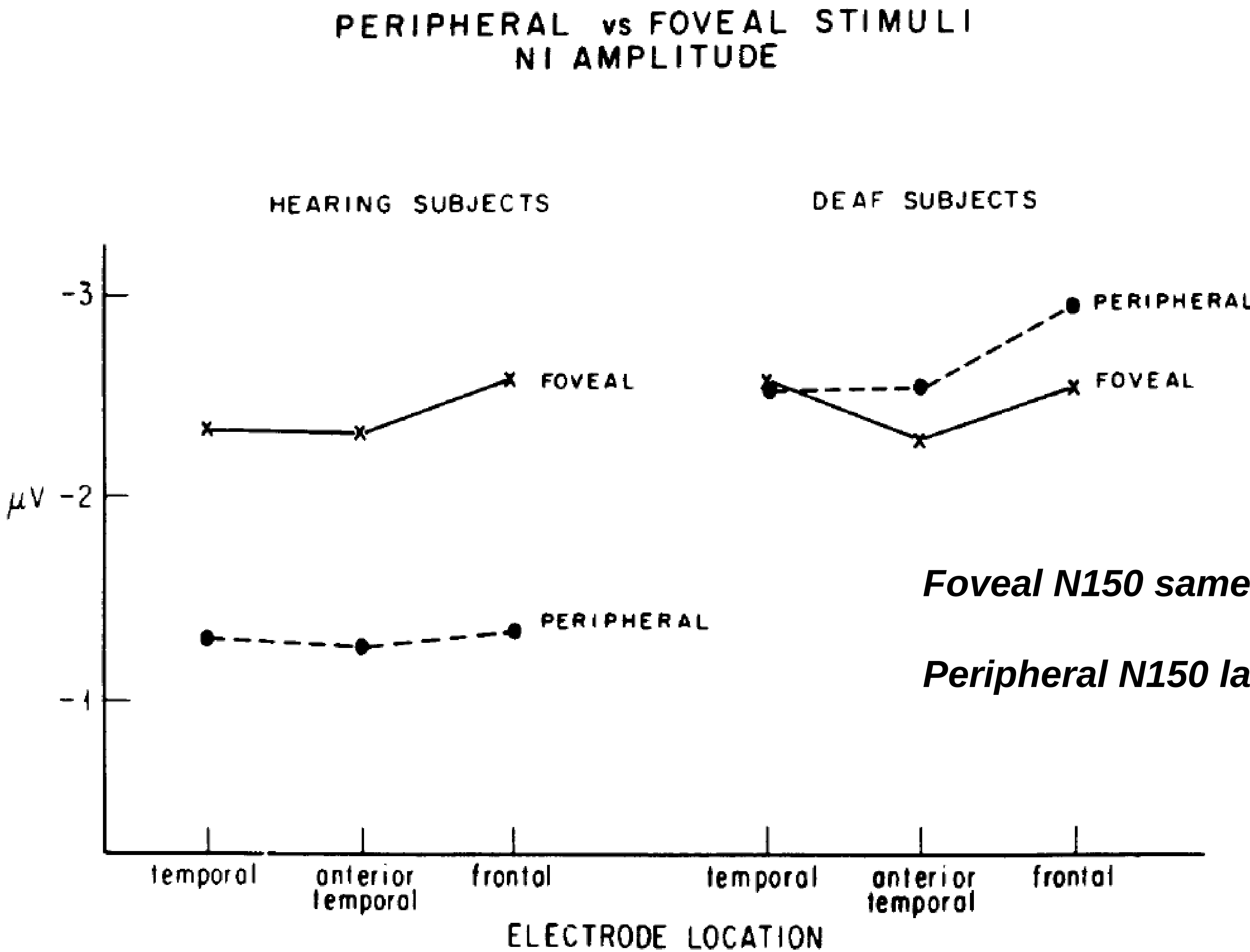


FIG. 17.1 Visual-evoked potentials (VEPs) from left frontal and anterior temporal electrodes to peripheral and foveal stimuli after the 3.0 second interstimulus interval. VEPs averaged over 13 normal-hearing (solid line) and 8 congenitally deaf (dashed line) adults are superimposed.



Foveal N150 same in two g

Peripheral N150 larger in d

FIG. 17.2 Amplitude in microvolts (uV) of VEP component N1 (150 msec) from 13 normal-hearing and 8 congenitally deaf adults, recorded from temporal, anterior temporal, and frontal regions to peripheral and foveal stimuli.

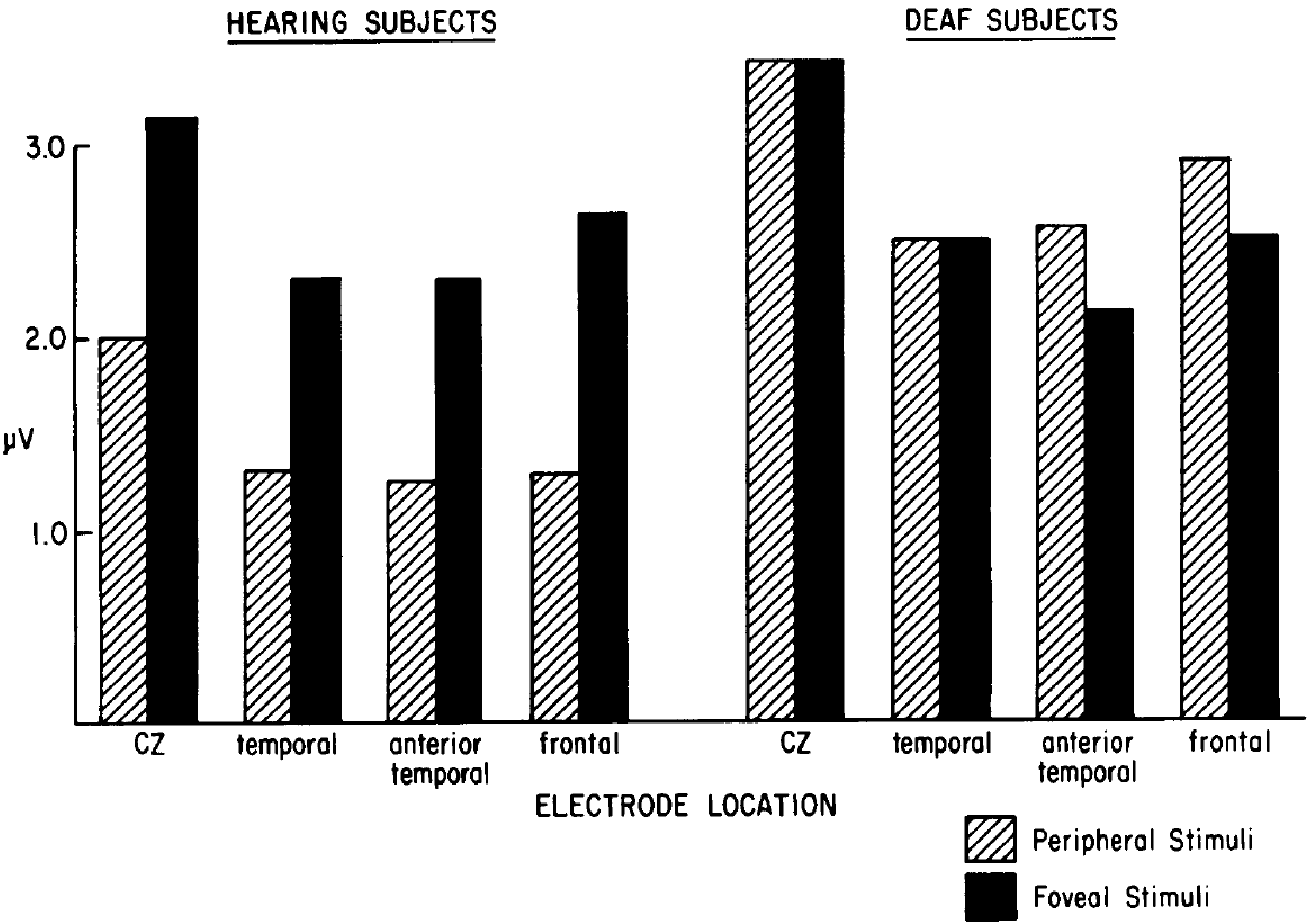
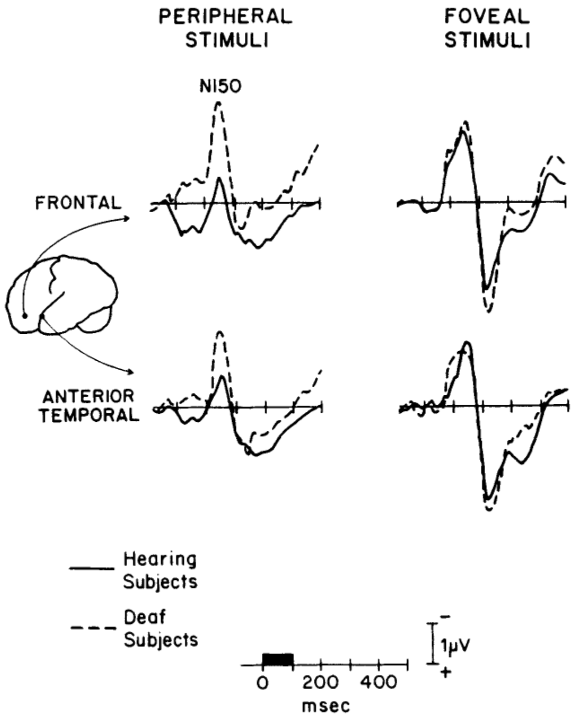


Fig. 2. Amplitude of N150 recorded from the vertex (CZ), temporal, anterior temporal and frontal regions to stimuli preceded by the 3.0 s ISI. Mean values from 13 normal hearing and 8 congenitally deaf adults for peripheral (dashed bar) and foveal (solid bar) stimuli.

352 NEVILLE



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Inferences??

Larger N150 over frontal and temporal areas in deaf relative to hearing is ***consistent with hypothesis that auditory areas deprived of their normal input have been reassigned to processing visual information.***

Specificity of enhancement to peripheral stimuli might reflect either less plasticity in foveal system or special compensation for peripheral sensory processing in deaf, who rely more on vision for localizing events in periphery.

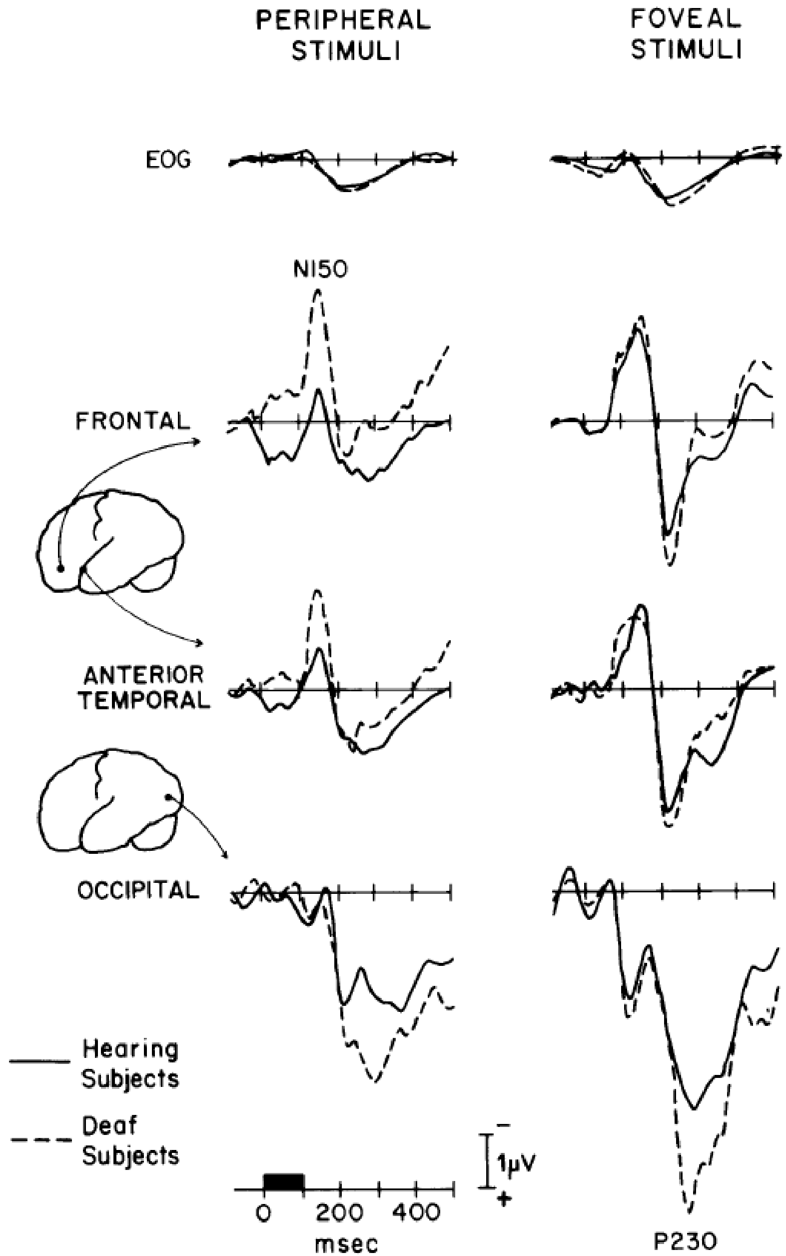


Fig. 1. Visual-evoked potentials (VEPs) from left frontal, anterior temporal and occipital electrodes to peripheral and foveal stimuli after the 3.0 s interstimulus interval. Also shown is the EOG recorded from under the left eye. VEPs and EOG averaged over 13 normal hearing (solid line) and 8 congenitally deaf (dashed line) adults are superimposed. The N150 component elicited by peripheral stimuli was larger from the contralateral than the ipsilateral hemisphere (mean amplitude all electrodes; hearing

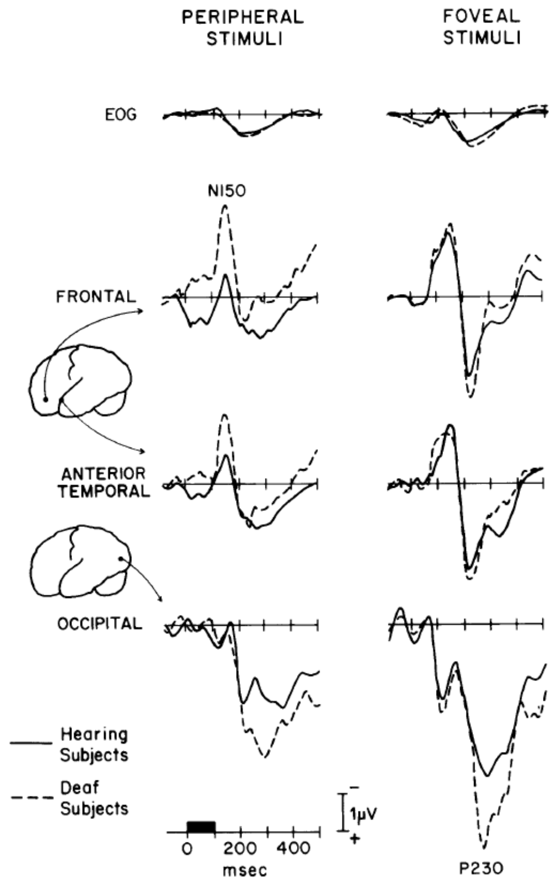


Fig. 1. Visual-evoked potentials (VEPs) from left frontal, anterior temporal and occipital electrodes to peripheral and foveal stimuli after the 3.0 s interstimulus interval. Also shown is the EOG recorded from under the left eye. VEPs and EOG averaged over 13 normal hearing (solid line) and 8 congenitally deaf (dashed line) adults are superimposed. The N150 component elicited by peripheral stimuli was larger from the contralateral than the ipsilateral hemisphere (mean amplitude all electrodes: hearing subjects contralateral −1.7 µV, ipsilateral −0.8 µV; deaf subjects contralateral −2.8 µV, ipsilateral −2.0 µV). However, as the effect of preceding ISI was independent of lateral visual field of stimulus presentation, the peripheral VEPs in Fig. 1 are collapsed across right and left visual field stimuli.

The increased amplitude of the P230 in the deaf over occipital regions of the scalp is ***consistent with structural changes observed in cortical areas associated with the intact modality.***

Neville & Lawson found that certain ERP component amplitudes to peripheral visual stimuli in congenitally deaf differ from that in normal hearing adults. There are (at least) two possible explanations for these differences:

1. ***altered auditory experience*** - sensory deprivation in one modality (e.g., deafness) impacts the activity of intact modalities (e.g., vision).

2. ***altered language experience*** - the acquisition of a visual signed language, In which grammatical and lexical information is conveyed through modulations of the shape, location and movement of the hands, influences the way certain visual stimuli in periphery are processed.

Neville and colleagues investigated visual ERPs in three participant groups:

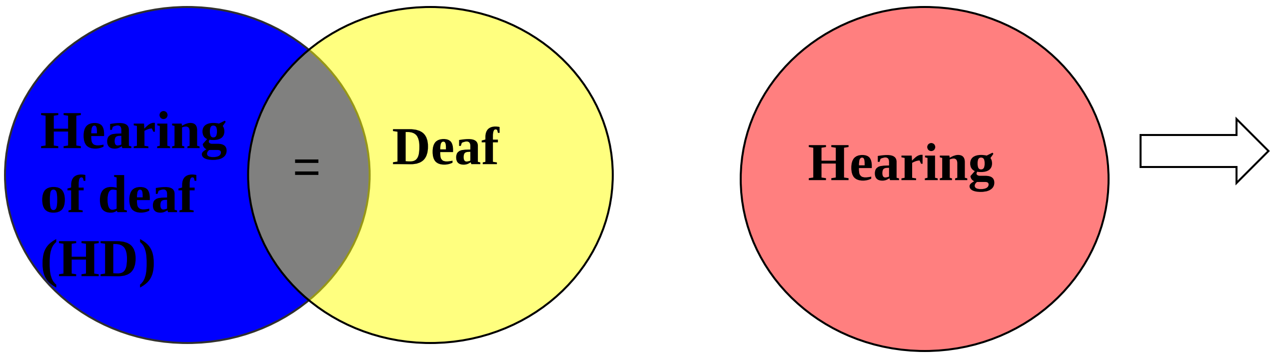
1. normal hearing (H)

2. congenitally deaf (deprived of auditory input since birth) (D)

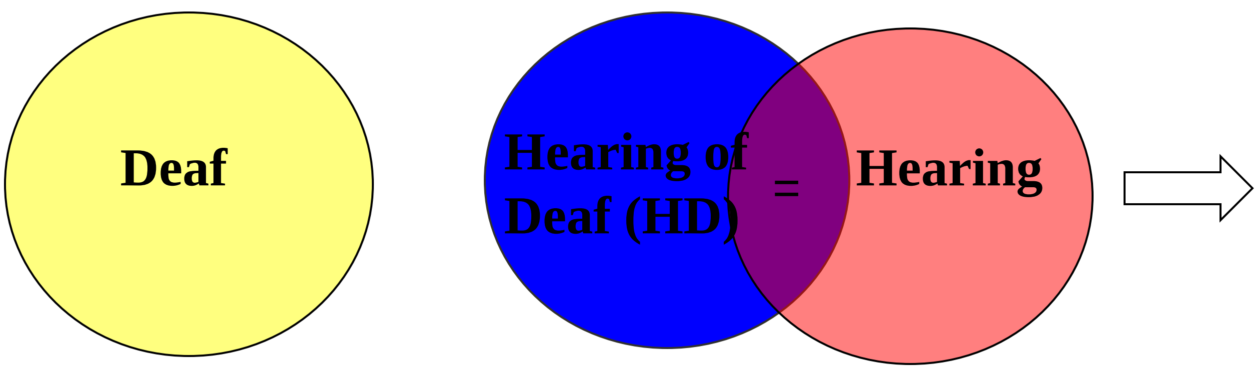
3. normally hearing adults whose first language was American Sign Language (ASL) by virtue of being born to deaf parents (HD)

With these groups it is possible to distinguish consequences of early auditory deprivation from those due to the acquisition of a visuo-spatial language (sign).

Dissociating effects of altered sensory and language experiences



More likely due to ASL experience



More likely due to auditory deprivation

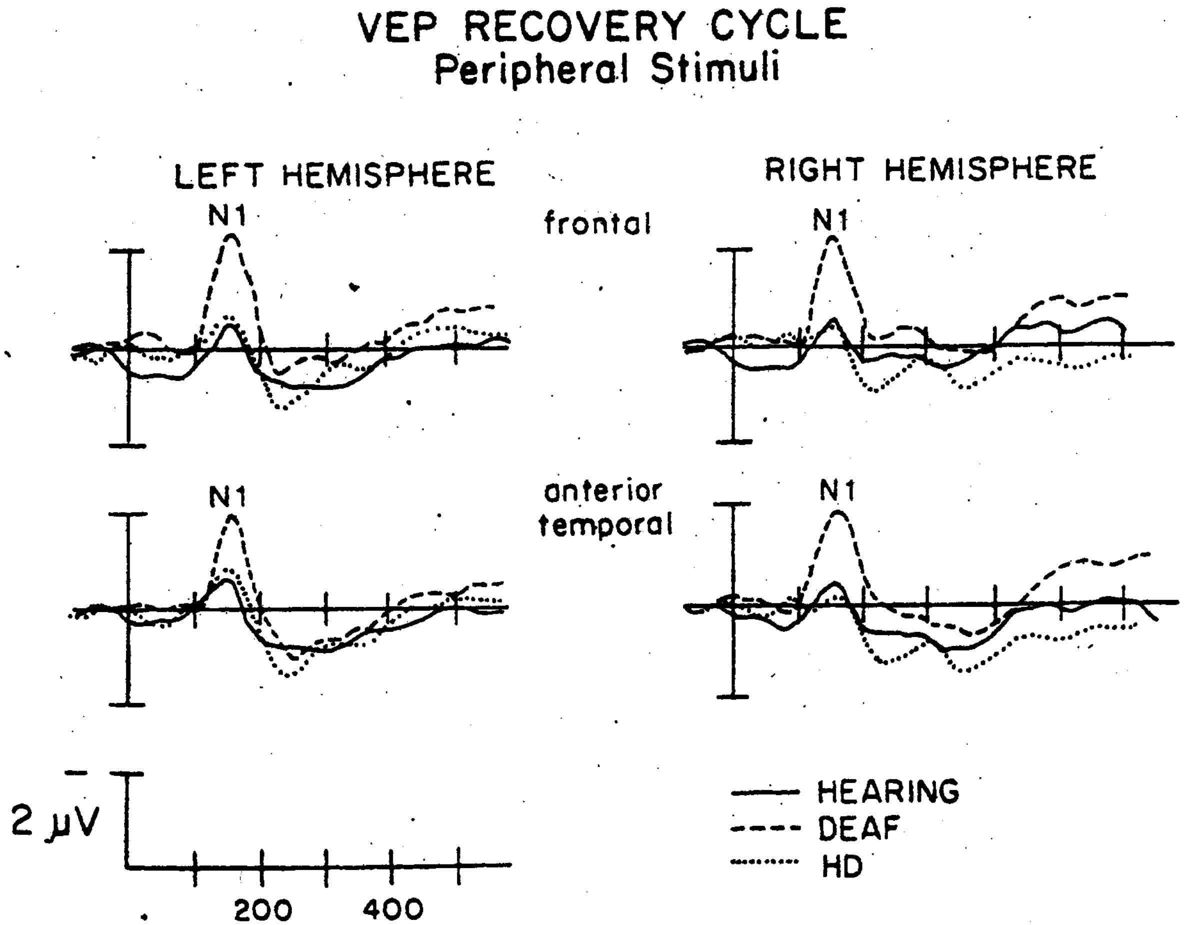


Fig. 6. ERPs to peripheral visual stimuli (summed across LVF and RVF) in the paradigm described in Neville et al.[44]. ERPs from hearing (——), deaf (----) and HD (....) Ss recorded over frontal and anterior temporal regions of the left and right hemispheres.

Neville et al. 1983

Visual spatial selective attention in congenitally deaf adults

Neville & Lawson

Stimuli & Task:
Standards: 80% of stimuli were white squares randomly presented centrally, to the left visual field (LVF) or to the right visual field (RVF).

Participants fixated a center point and focused their attention on stimuli in one of the 3 locations (center, left, right visual fields). Their task was to indicate the direction of motion of the Target (20%) stimuli (one out of 8 possible directions).

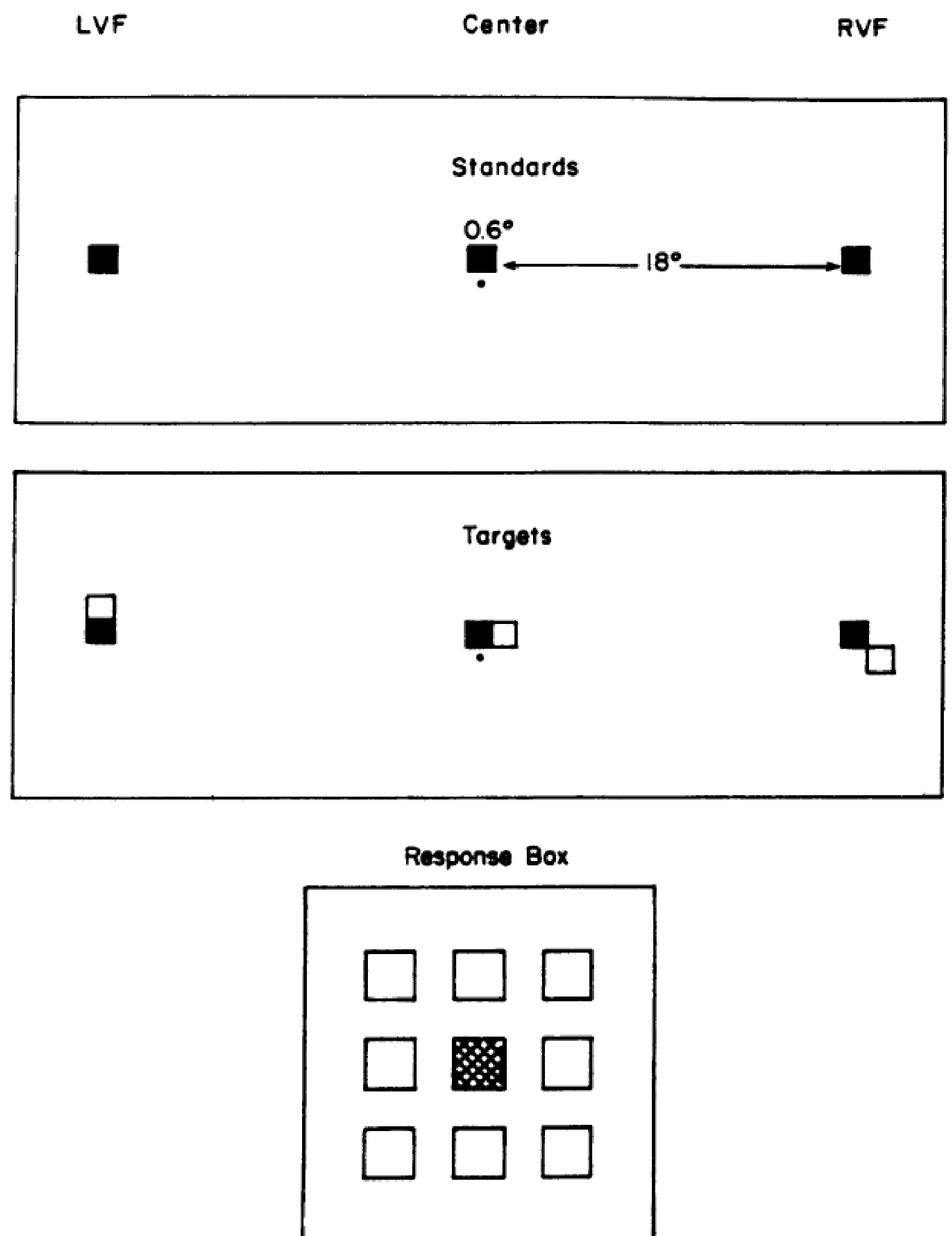
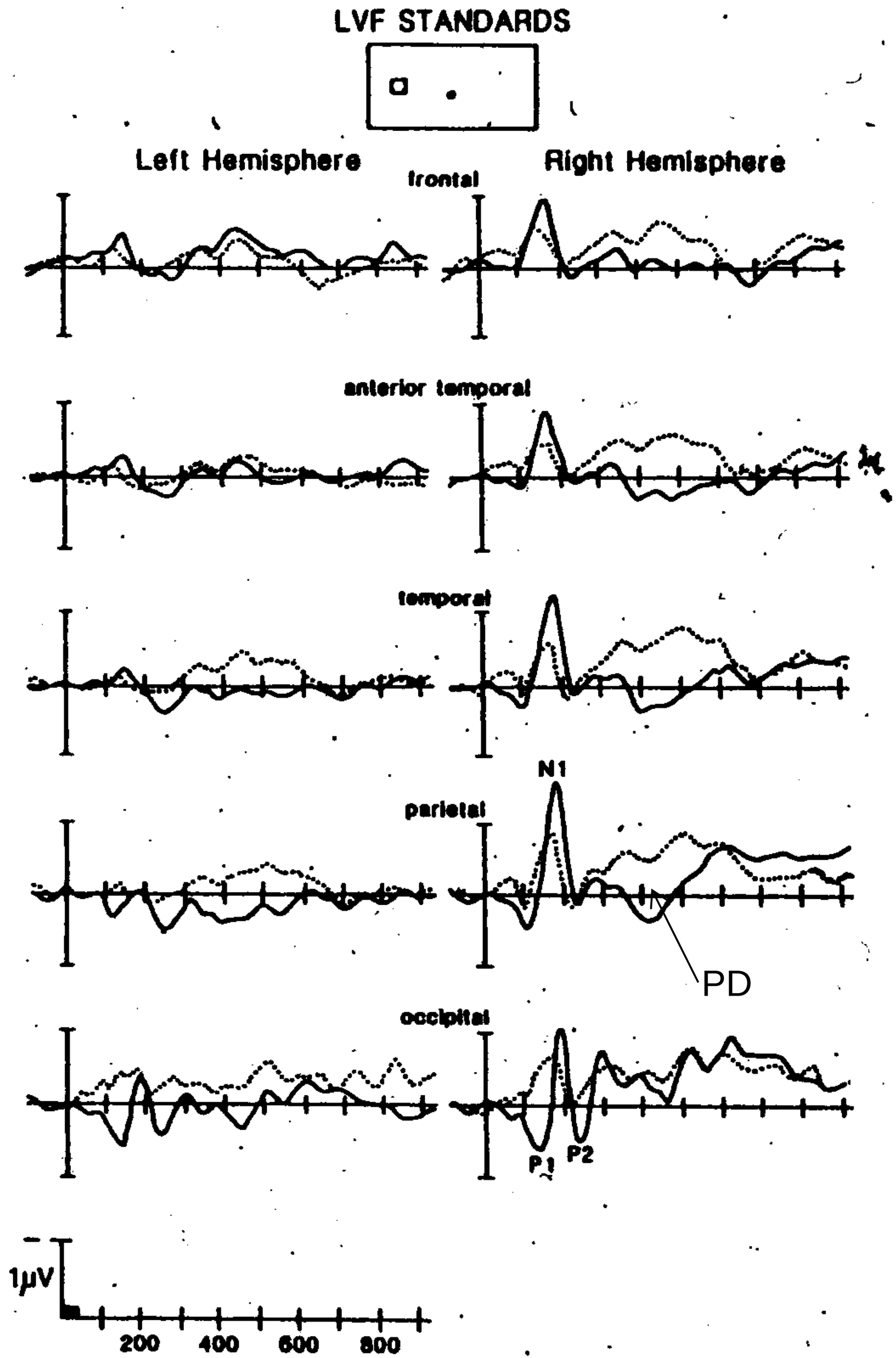


FIGURE 2. Stimuli for visual attention paradigm. Target stimuli were perceived as moving along horizontal, vertical, or diagonal axes. Subjects pressed one of eight buttons on the response box to indicate the perceived direction of motion.


LVF STANDARDS
Left Hemisphere
Right Hemisphere
frontal
anterior temporal
temporal
parietal
occipital
N1
PD
P1
P2
1μV
200
400
600
800

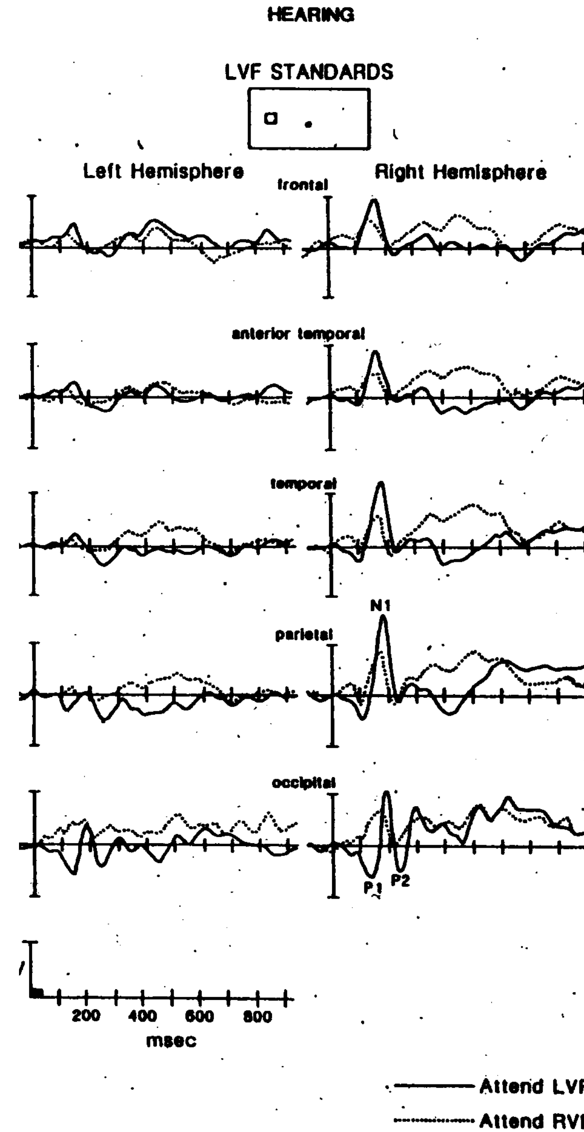
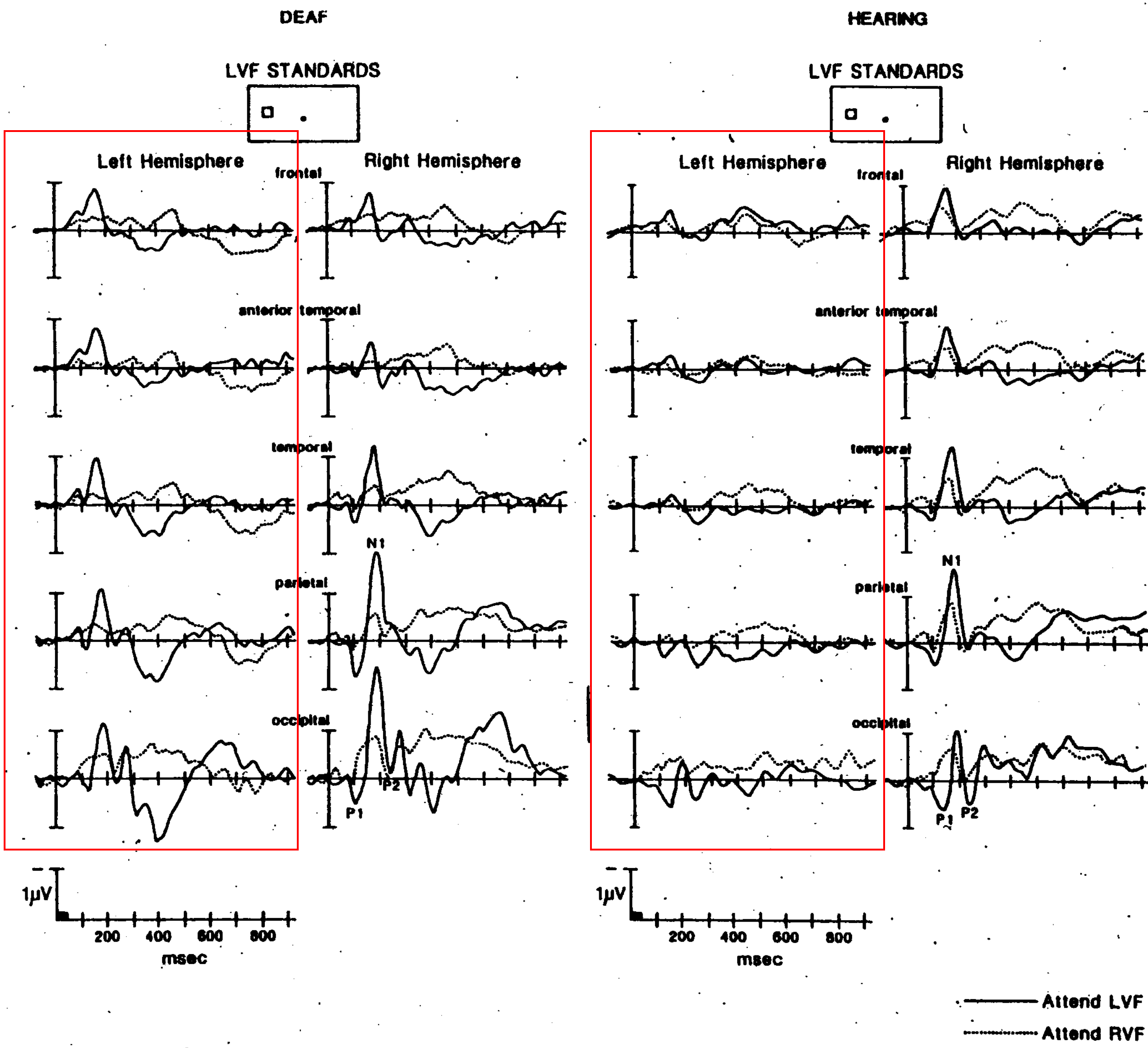


Fig. 1. ERPs averaged across 12 HD subjects (left panel), 12 deaf Ss (center panel) and 12 hearing Ss (right panel) to standard stimuli presented to the left visual field (LVF) when attended (attending LVF) and when inattended (attending RVF). Recordings from left and right frontal, anterior temporal, temporal, parietal and occipital cortex.

Two major differences between hearing and deaf:

1. Deaf show large attention effects not only in the right hemisphere like hearing, but also in the left hemisphere, i.e., the deaf have large N1 effects over left hemisphere regardless of visual field of presentation.



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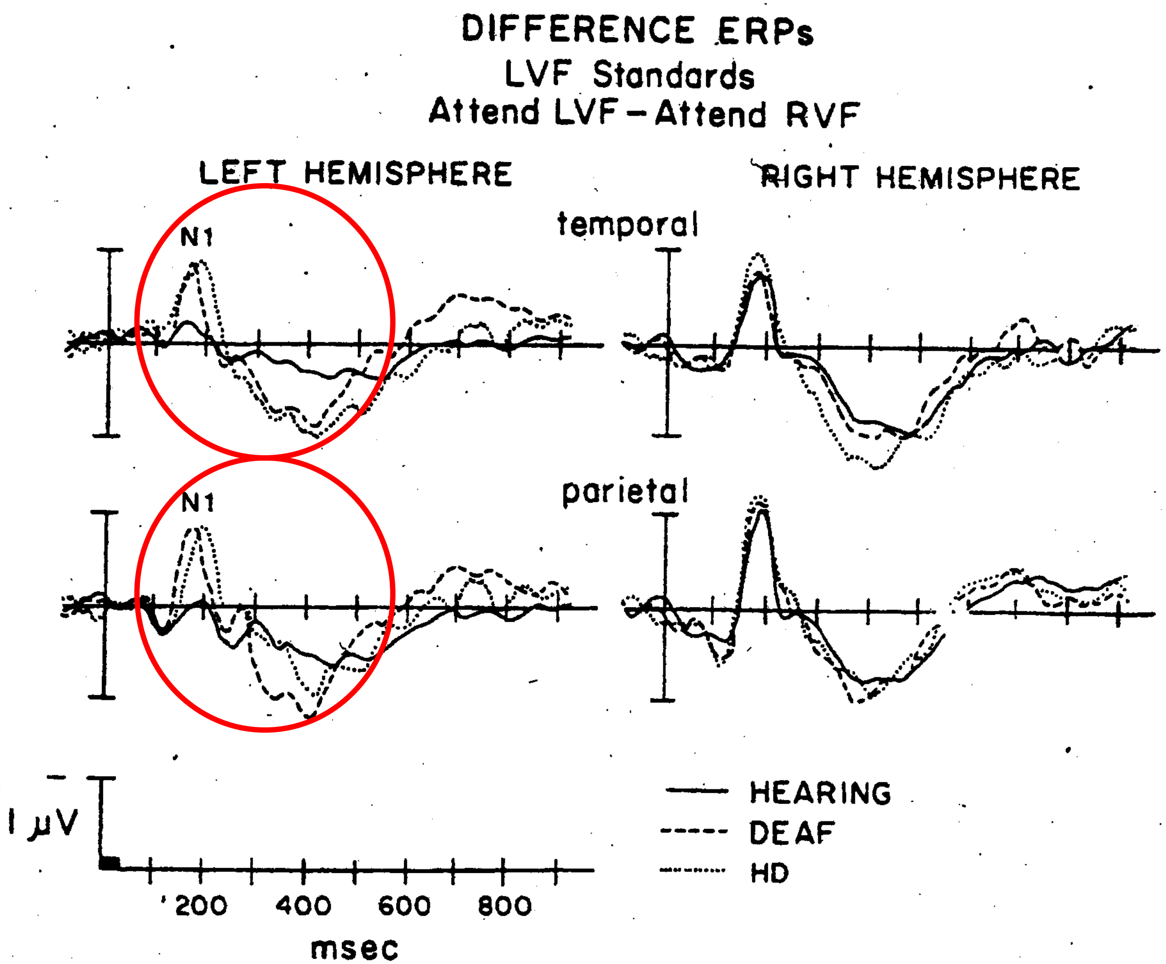


Fig. 2. Difference ERPs, formed by subtracting ERPs to inattended LVF stimuli from ERPs to the same stimuli when attended, from hearing, deaf and HD Ss. Recordings from left and right temporal and parietal regions.

N1 and PD attention effects over left hemisphere sites are seen in both deaf and HD, thus probably due to their differential language experience compared to hearing.

Two major differences between hearing and deaf:

1. Deaf show large attention effects not only in the right hemisphere like hearing, but also in the left hemisphere, i.e., the deaf have large N1 effects over left hemisphere regardless of visual field of presentation.

2. Deaf show larger N1 effects and large PD components at occipital sites.

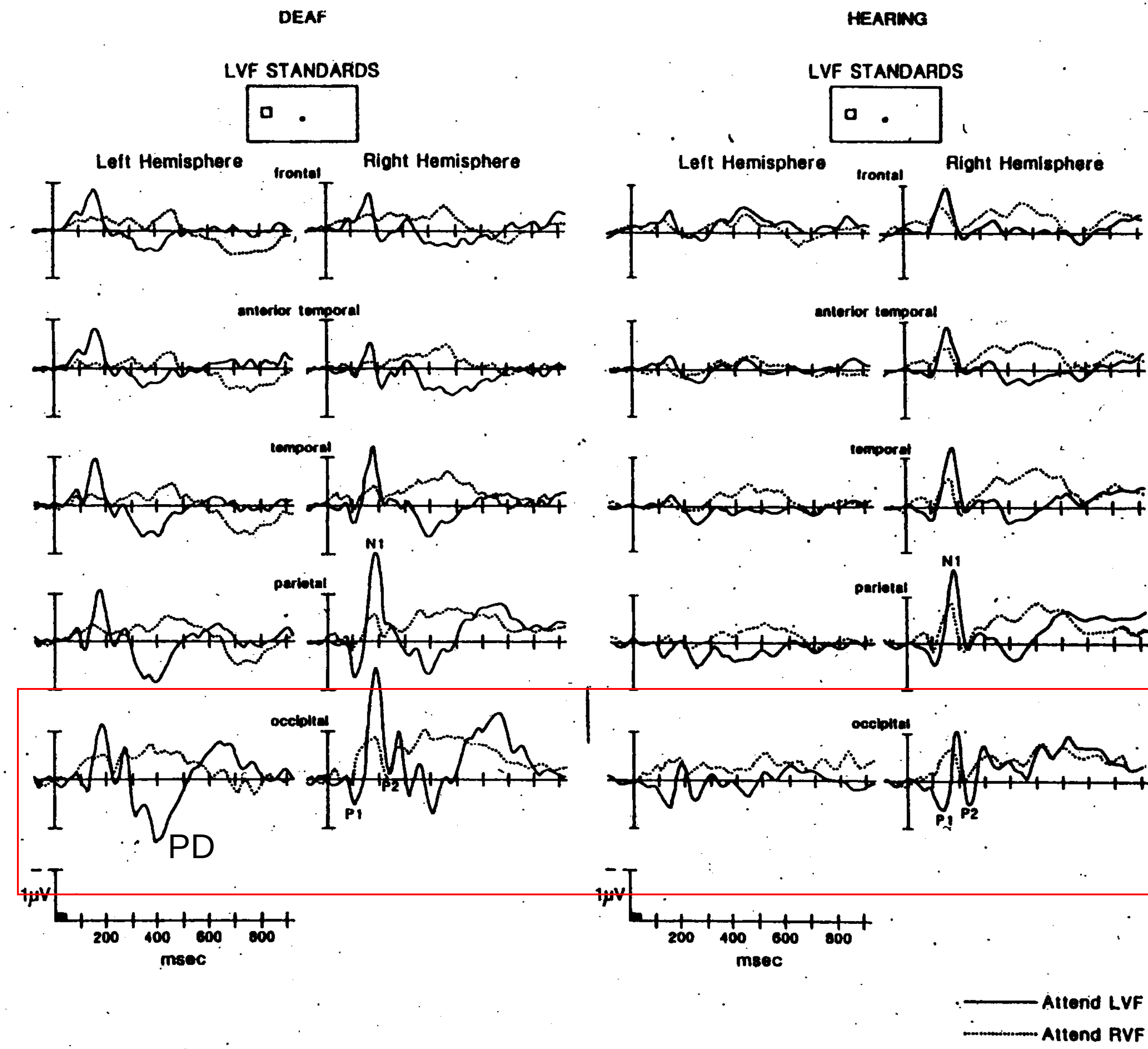


Fig. 1. ERPs averaged across 12 HD subjects (left panel), 12 deaf Ss (center panel) and 12 hearing Ss (right panel) to standard stimuli presented to the left visual field (LVF) when attended (attending LVF) and when inattended (attending RVF). Recordings from left and right frontal, anterior temporal, temporal, parietal and occipital cortex.

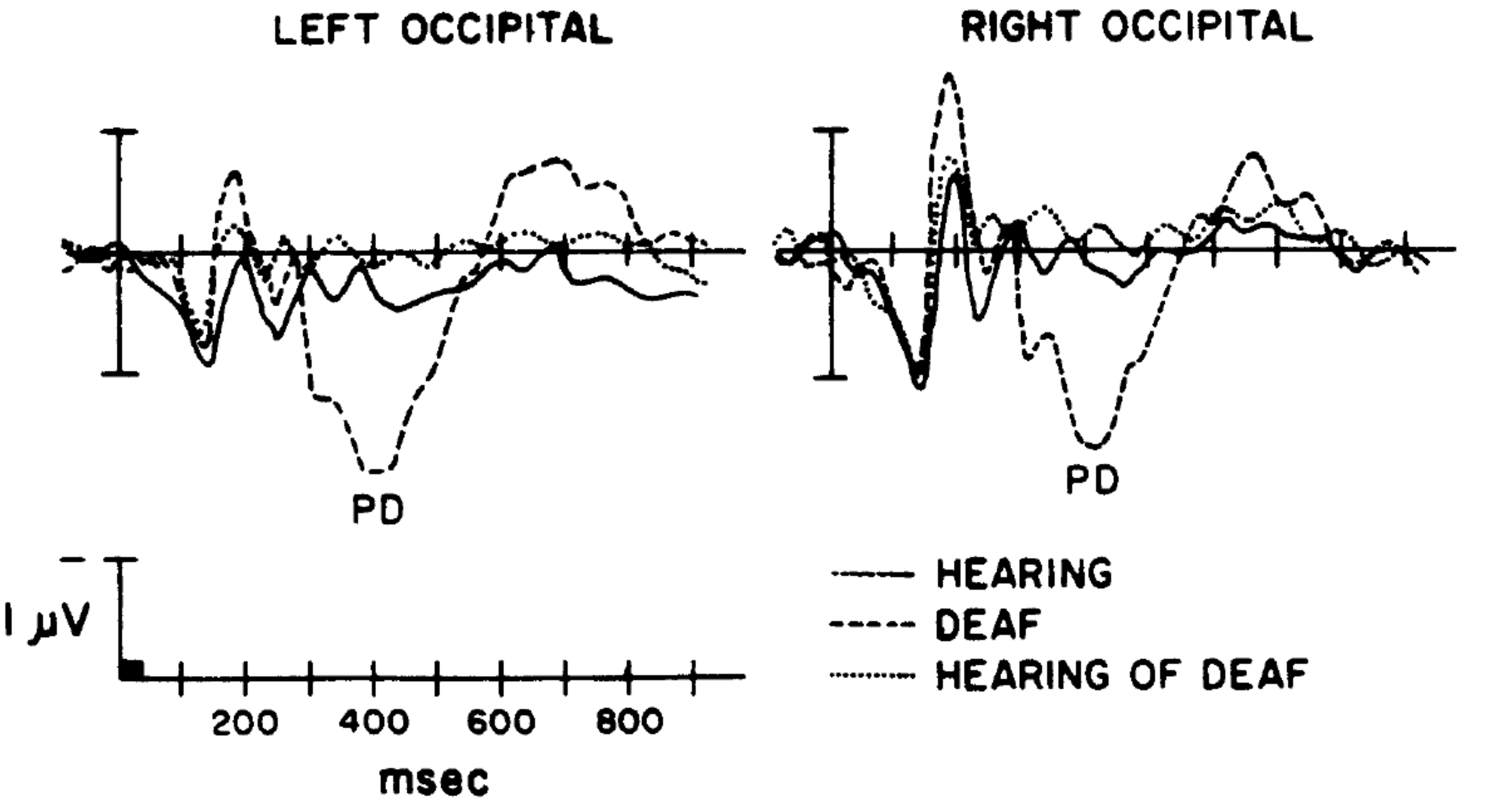


FIGURE 6. Difference ERPs, formed by subtracting ERPs to inattended lvf stimuli from ERPs to the same stimuli when attended, from hearing subjects, deaf subjects, and hearing subjects born to deaf parents, recorded over left and right occipital regions. (Reprinted from Neville and Lawson, 1987c, with permission from *Brain Research*.)

Occipital effects in deaf seem to be due to auditory deprivation as they are not seen either in normally hearing or in hearing of deaf (signers).

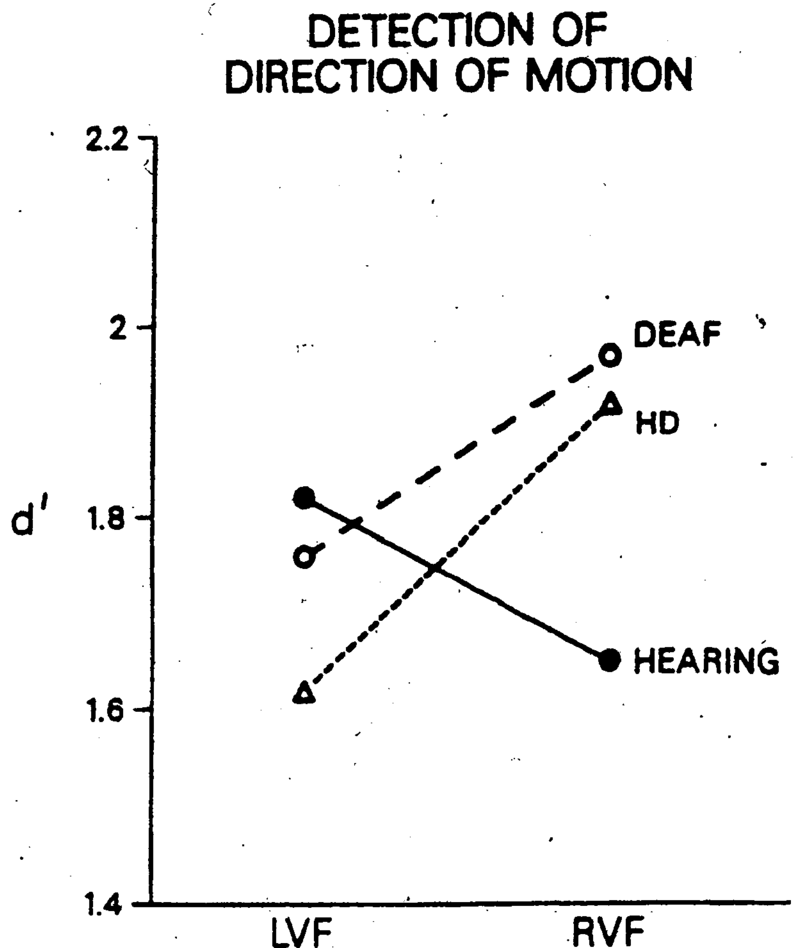


Fig. 5. Detection (d′) of motion of targets in the left and right visual fields (LVF and RVF) for hearing (——), deaf (----) and HD (. . . .) Ss.

Detection of motion in the two visual fields is similar for deaf and HD (showing RVF advantage) relative to hearing (who show LVF advantage) ; thus, likely due to experience with ASL.

Neural systems that mediate attention to visual space and perception of motion are different in normally hearing and congenitally deaf individuals.

The major group differences occur in the systems that mediate perception and attention to peripheral but not central visual space. For peripheral stimuli, the ERP data indicate a greater involvement of the right and left occipital regions as well as a greater role for the left hemisphere for the deaf.

The increases in amplitudes over *left temporal and parietal* regions with attention to periphery show left hemisphere specialization for the perception of peripheral motion in both deaf and hearing native signers, who acquired sign language early in development

The increases in amplitudes over *bilateral occipital* region with attention to periphery in congenitally deaf may be interpreted as evidence for compensatory alterations in the visual system secondary to auditory deprivation.

Abnormal early sensory experience - visual deprivation

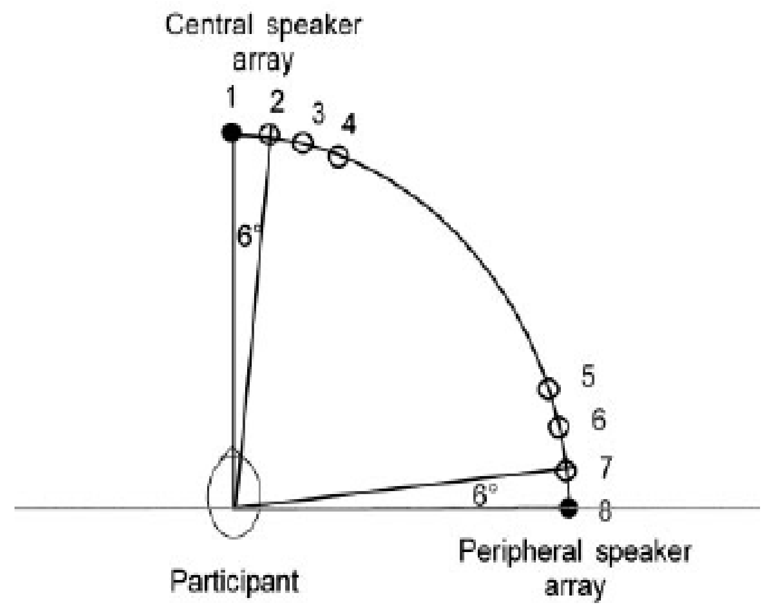
Auditory spatial attention in blind humans (*Roder, Hillyard, & Neville*)

Hypothesis: effects of visual deprivation might be more pronounced for processing peripheral sounds.

Dependent variable: attention effect on auditory N1 component (N1 and/or Nd)

Array of 8 speakers: 4 in front of the subjects and 4 in the right periphery.

Rapid sequences of standard and deviant sounds were presented randomly in all speakers, while participants attended only one of the speakers. Respond to higher pitch target stimuli in attended channel.



Compare congenitally blind subjects to blindfolded sighted control subjects.

Behavioral results

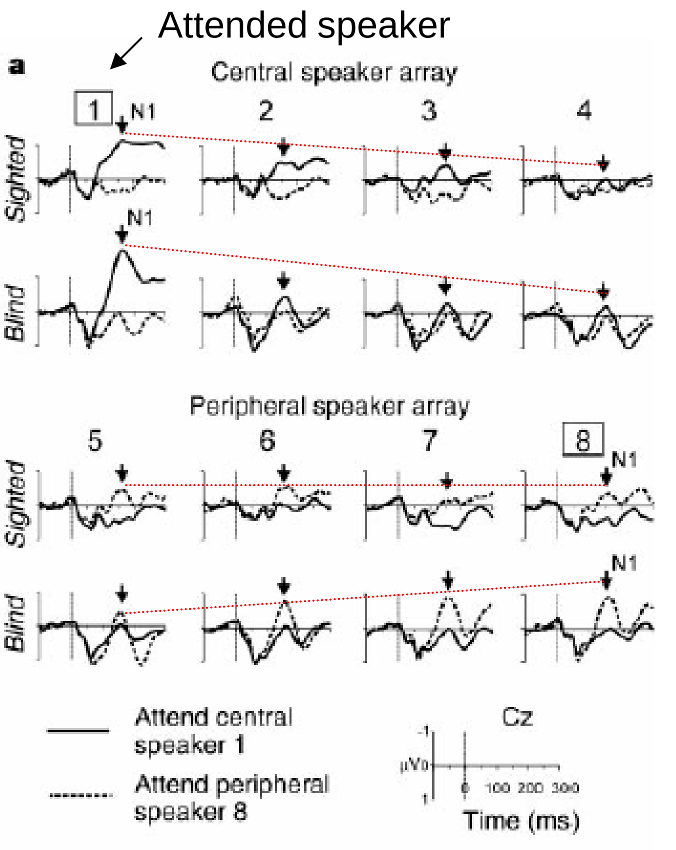
While attending speaker 1 (central speaker), both groups were highly accurate at detecting the deviant sounds from the attended speaker.

While attending speaker 8 (peripheral speaker), both groups were less accurate and made more false alarms to the adjacent speakers. However, the proportional decline in response rate between the attended and adjacent speakers was greater for the blind, indicating a more narrow focusing of attention on the peripheral target location.

Central and Peripheral N1 attention effects

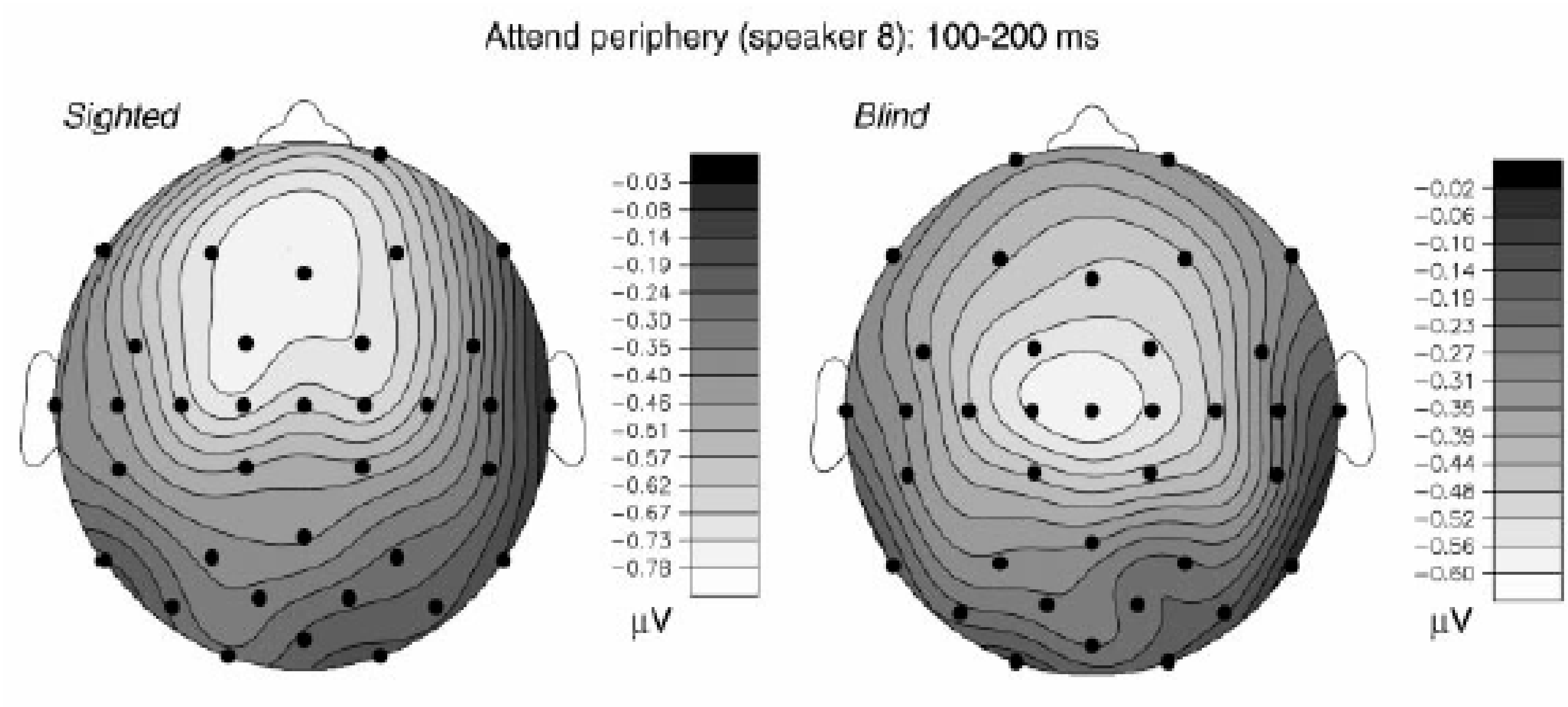
N1 attention effect decreased progressively in response to sounds increasingly more distant from the attended speaker; this attentional gradient was steeper for attention to central compared with peripheral space.

The N1 attentional gradient did not differ significantly between the blind and sighted when attending to the center speaker. However, with attention to the periphery, the N1 attentional gradient was significantly steeper for the blind than for the sighted participants.



Blind participants exhibited better focusing of auditory attention in the periphery compared to normally hearing individuals.

Scalp distribution of N1 attention effect in auditory periphery



Scalp distribution of the N1 attention effect for items in the periphery differs between blind and sighted participants: enhanced N1 effect was largest over the anterior scalp in sighted participants and over centro-posterior scalp in the blind participants. These distributional differences suggest that neuronal populations engaged are somehow different in the two groups for the same task. This is suggestive of functional reorganization.



A conductor is regularly faced with the task of simultaneously monitoring the performance of the orchestra as a whole as well as of individual musicians: this requires especially good auditory spatial resolution skills.

Hypothesis: conducting alters auditory spatial processing such that conductors have superior auditory spatial attention skills.

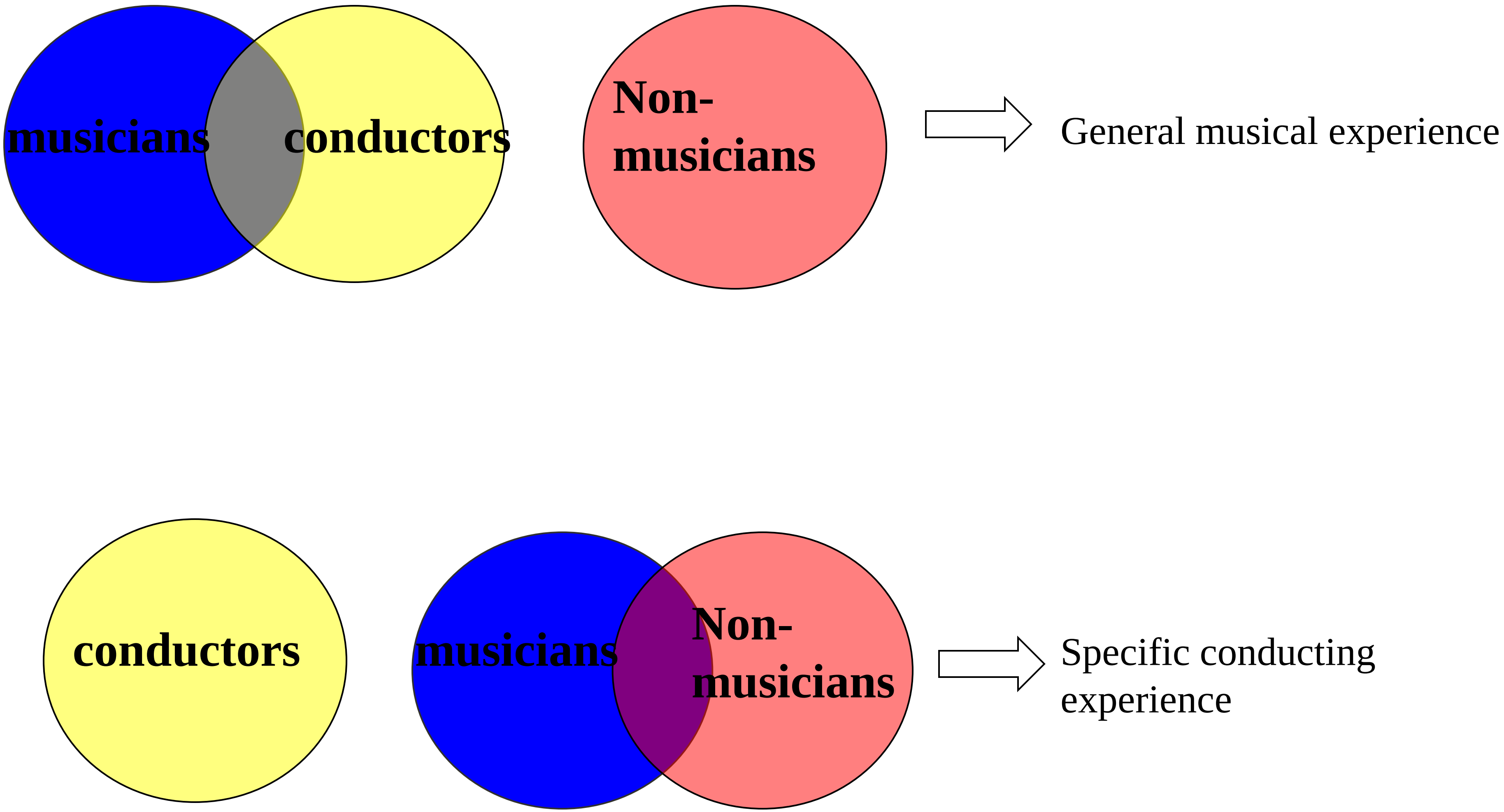
Participant groups:

Non-musical controls

Conductors

Who else as control?

To dissociate effects specifically due to conducting experience versus those due to more general long term musical experience.



Auditory spatial attention in conductors (*Munte et al*)

Brief noise bursts presented in a random sequence with equal probability from 6 speakers: 3 central and 3 peripheral.

84% standards; 16% higher pitch deviants.

Central condition: detect infrequent deviants in the central speaker C1 (ignore all others).

Peripheral condition: detect deviants in the peripheral speaker P1 (ignore all others).

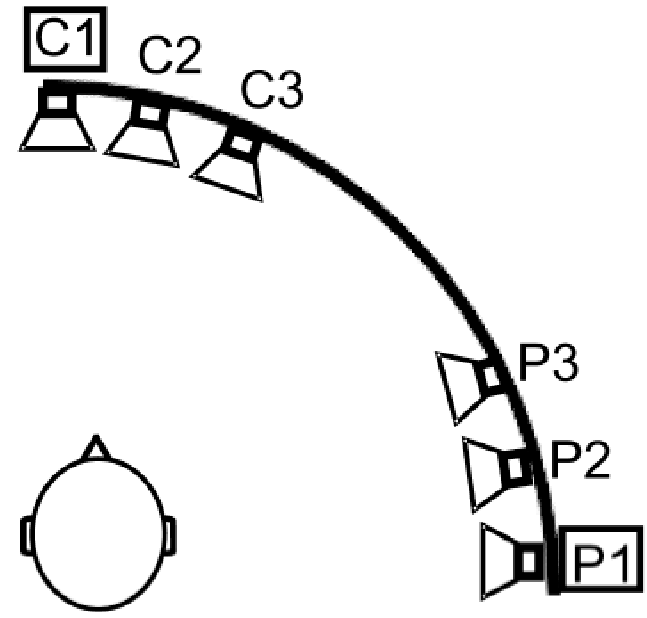
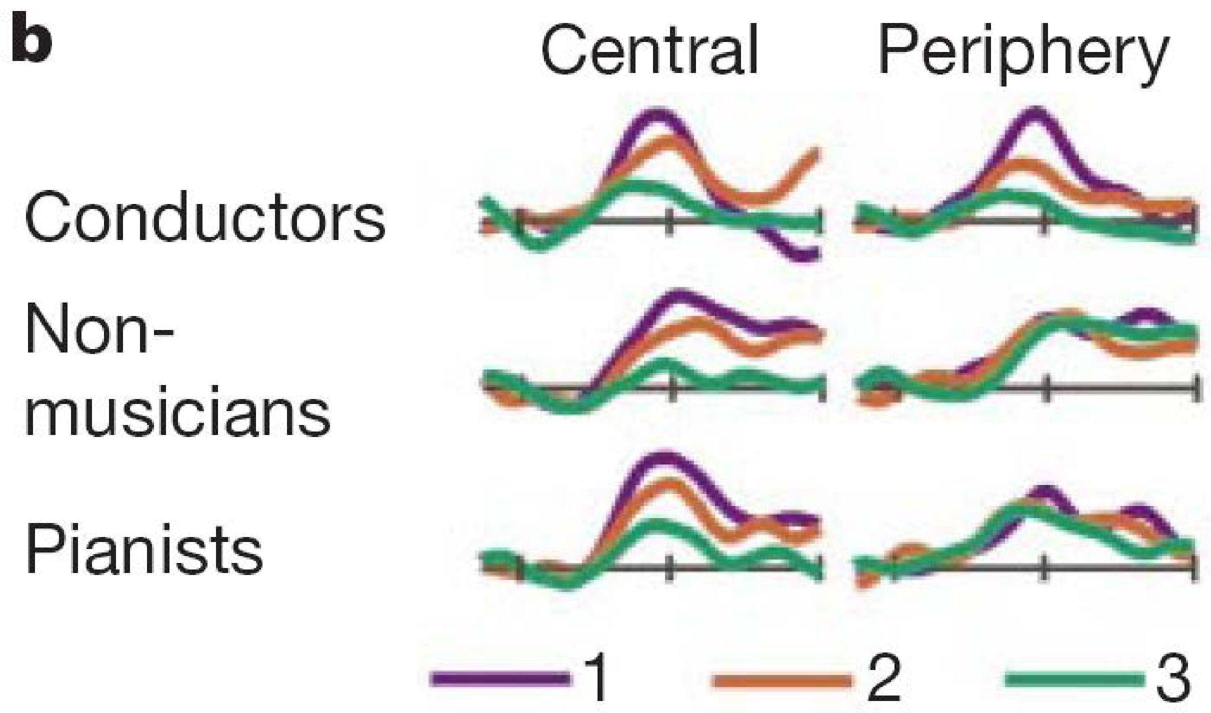


Fig. 1. Schematic drawing of experimental set-up.

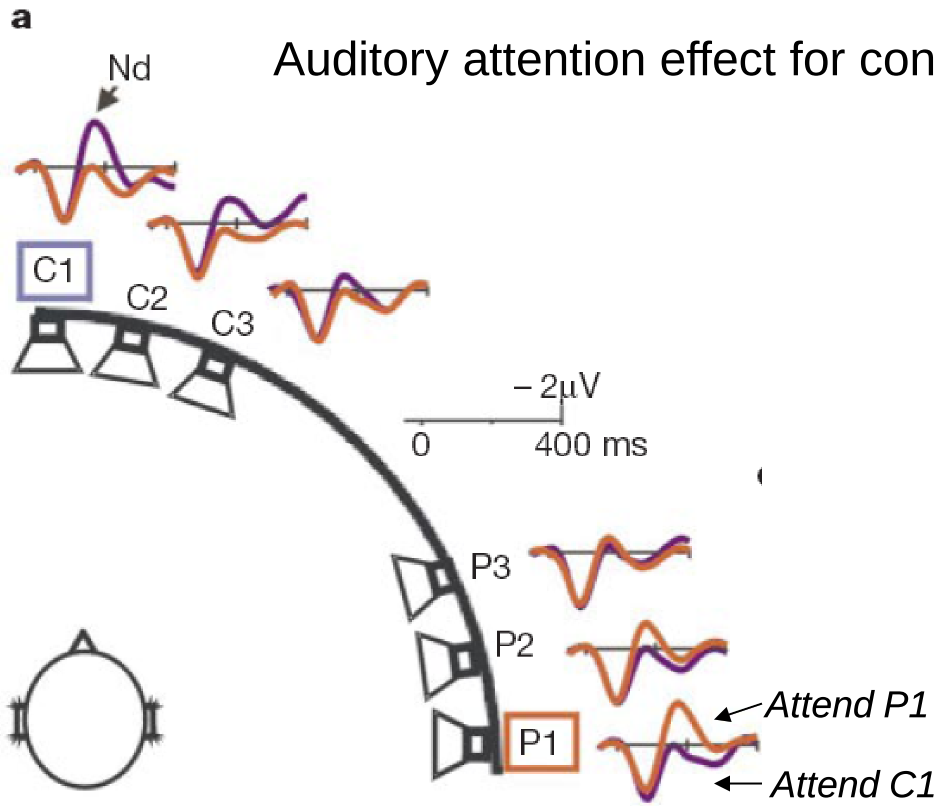
All groups showed a good selectivity for stimuli in the central speakers - -
- high hit rates
- low false alarm rates).

However, conductors were better in the periphery. Conductors made fewer false alarms to deviants from neighboring speakers during the attend periphery condition, indicating better selectivity.



All three groups show a gradient in Nd amplitude, largest for attended channel, and decreasing with increasing distance from attended channel, when attention is directed to the center. Only conductors show gradient for attention to periphery.

Auditory attention effect for conductors



Attend C1 (blue) vs Attend P1 (brown)

Scalp distribution of the attention effect was very similar for controls, pianists, and conductors, suggesting that they all use the same cortical brain mechanisms to perform this attention task, even if the conductors are overall much better at it.

GENERAL CONCLUSIONS

The results suggest that across auditory and visual modalities the representation of peripheral space is more altered by sensory experience than is the representation of central space.

Conductors and congenitally blind subjects both need fine auditory spatial resolution, and the modulation of the auditory attention effect is similar in these two groups. The scalp distribution data in the two groups, however, suggest that they seem to use different mechanisms for the improved processing in the periphery.

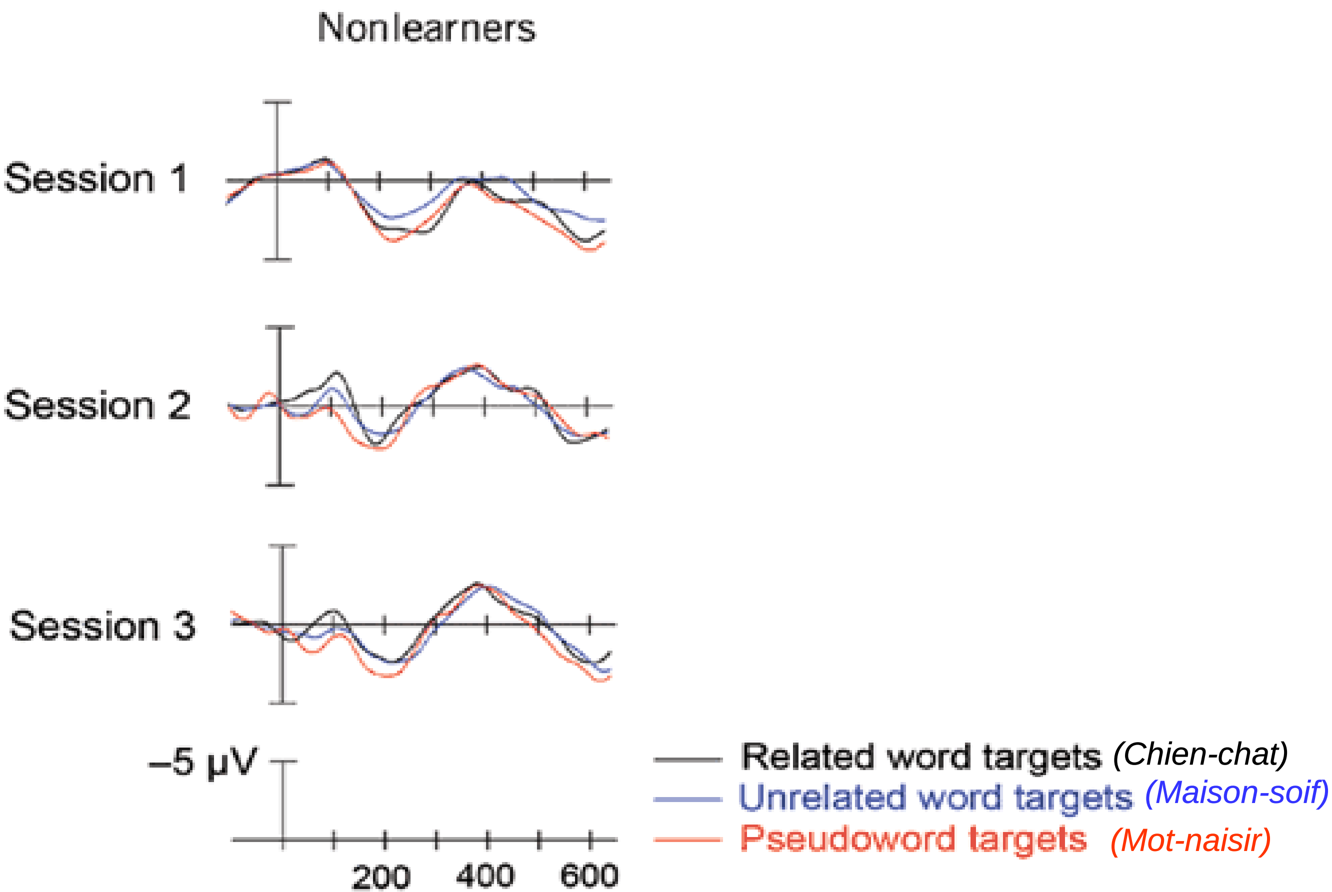
Second language learning

Semantically Related Word pairs: *chien-chat*

Semantically Unrelated Word pairs: *maison-soif*

Word-pseudoword pairs *mot-naisir*

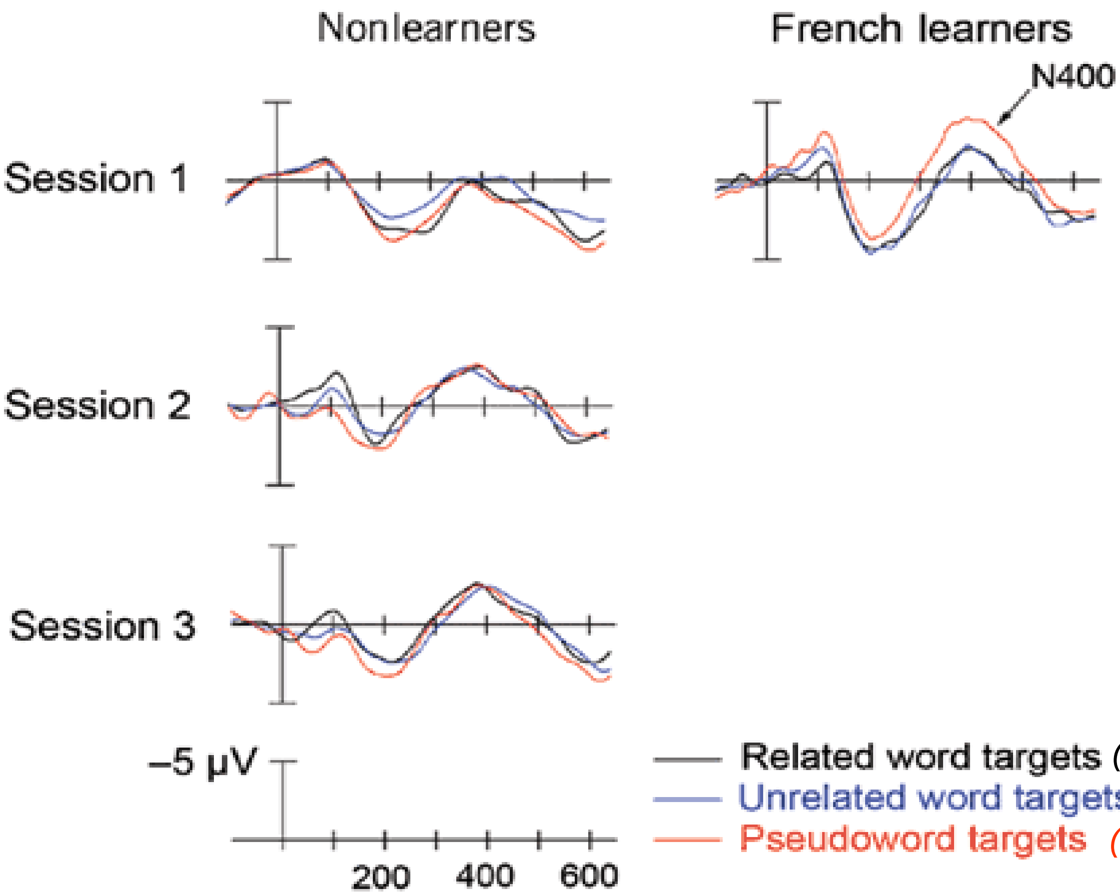
Second language word learning



d' measure: 0 – no sensitivity, 4 = perfect sensitivity

McLaughlin, Osterhout, Kim (2004)

Second language word learning



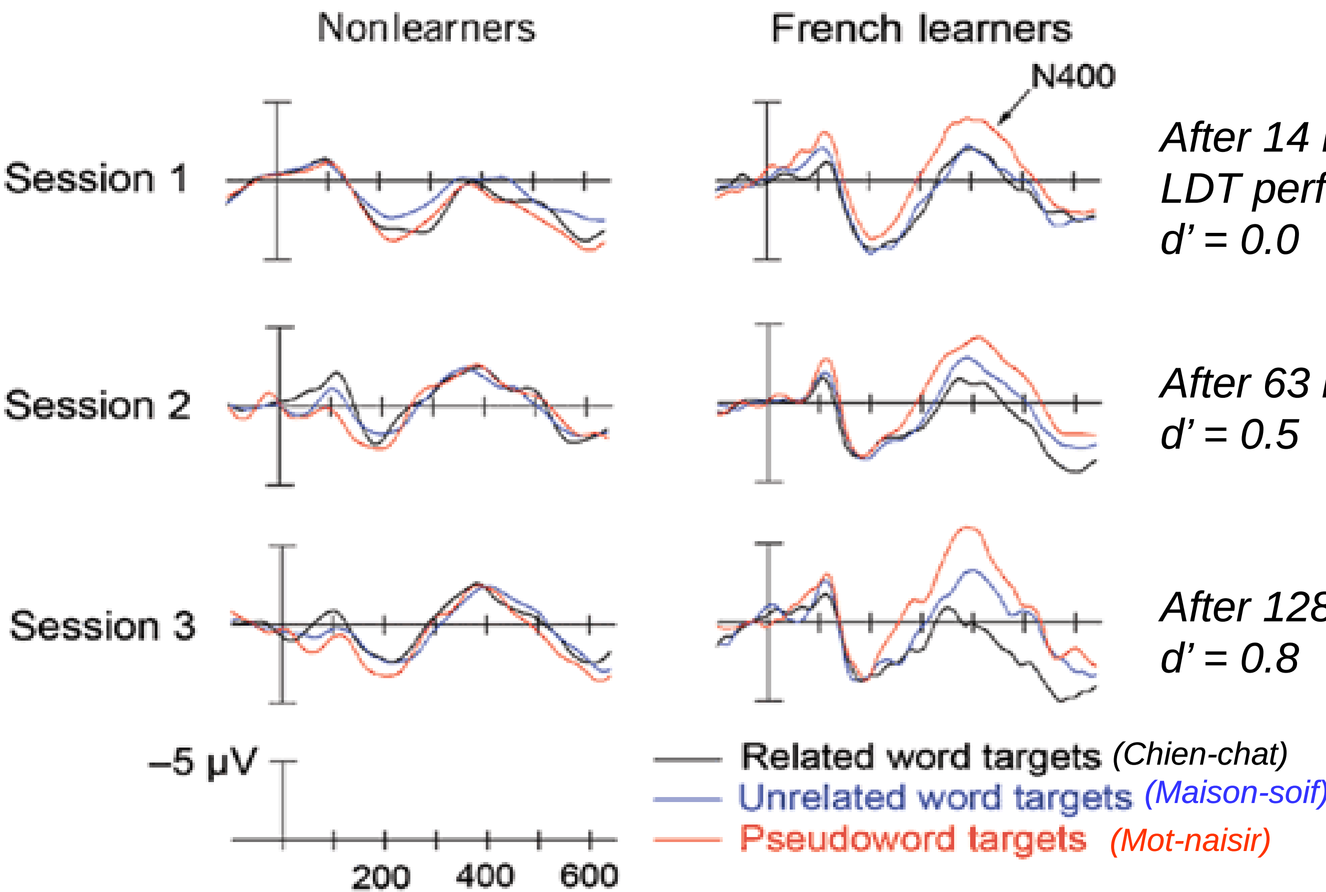
(Chien-chat)
(Maison-soif)
(Mot-naisir)

After 14 hrs hours instruction LDT performance at chance, d' = 0.0

d' measure: 0 – no sensitivity, 4 = perfect sensitivity

McLaughlin, Osterhout, Kim (2004)

Second language word learning



After 14 hrs hours instruction LDT performance at chance, d' = 0.0

After 63 hrs hours instruction d' = 0.5

After 128 hrs hours instruction d' = 0.8

d' measure: 0 – no sensitivity, 4 = perfect sensitivity

McLaughlin, Osterhout, Kim (2004)

ERPs are a good measure of synaptic plasticity…

The changes in ERP indices of neural processing as a function of experience can be used to investigate the effects of various instruction methods (massed versus spaced, immersion versus pictorial), similarity between the first and second language at multiple levels, age of acquistion, etc. …and how these play out in language competence and performance.