

SH 809: The Onset of Visual Experience Gates Auditory Cortex Critical Periods

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Agenda

- Developmental plasticity
- Cross-modal plasticity
- Proving plasticity at biological level
 - Natural eyelid opening
 - Early visual experience
 - Delayed visual experience
 - Recovering from transient hearing loss
 - Anatomical tracing
- Conclusion
- Discussions

Developmental Plasticity

- Previous works by the same lab have shown that normal maturation of cortical inhibitory synapse function is dependent on auditory experience during critical period.
 - Basically they found that conductive hearing loss (CHL) induced early on induced changes in intrinsic and synaptic properties of inhibitory interneurons.
 - When CHL was induced late in adulthood, they found no effect on sIPSC and me-IPSC in L2/3 cortical pyramidal cells.
- Takesian, Anne & Kotak, Vibhakar & H Sanes, Dan. (2011). Age-dependent effect of hearing loss on cortical inhibitory synapse function. *Journal of neurophysiology*. 107. 937-47. 10.1152/jn.00515.2011.
- Mowery, Todd & Kotak, Vibhakar & H Sanes, Dan. (2014). Transient Hearing Loss Within a Critical Period Causes Persistent Changes to Cellular Properties in Adult Auditory Cortex. *Cerebral cortex (New York, N.Y. : 1991)*. 25. . 10.1093/cercor/bhu013.

Cross-Modal Plasticity

- “Deprivation of one sensory system (especially during critical periods) can lead to (maladaptive) reorganization of neuronal arbors; thereby allowing them to integrate the function of two or more intact sensory system.”
- This study will examine effect of visual system on auditory system on biological perspective.

Experiment Set-up

- 174 gerbils (*Meriones unguiculatus*), 695 pyramidal neurons
- Bilateral earplugs to simulate mild hearing loss (sound leak?) Not permanent.
- Bilateral eye gluing, not permanent.
- Early eyelid opening, permanent.
- Dark rearing

Experiment Set-up (Pt 2)

- Thalamocortical brain slice preparation
- Functional auditory-visual brain slice preparation
- Whole-cell voltage-clamp recordings to record membrane and synaptic properties (sIPSC amplitude, frequency, decay and mIPSC)
- Whole-cell current-clamp recordings- for ACx response to stimulation of both MG and VCx.

Gerbils

- Gerbils are born deaf and blind.
- Natural eyelid opening at P17 (variance unknown but authors seems to assume all eyelids open around the same day)
- Become hearing at P5 (variance unknown)
- CP for hearing – not mentioned in paper but I assume it started from P5.

Review of Experimental Design

- Seems well-designed

Natural Eyelid Opening

- 3 groups
- Decrease in sIPSC amp (pA) and freq (Hz) and increase in sIPSC decay (ms) can negatively impact temporal processing of auditory stimulus.
- Implies that auditory experience is critical

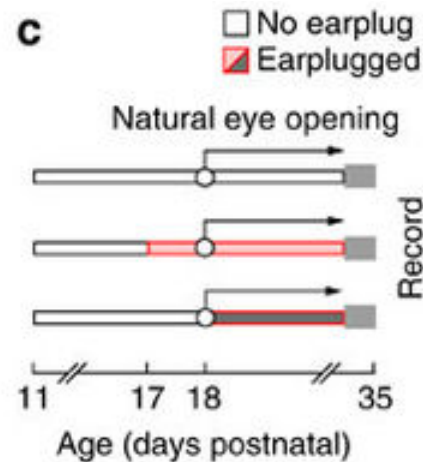
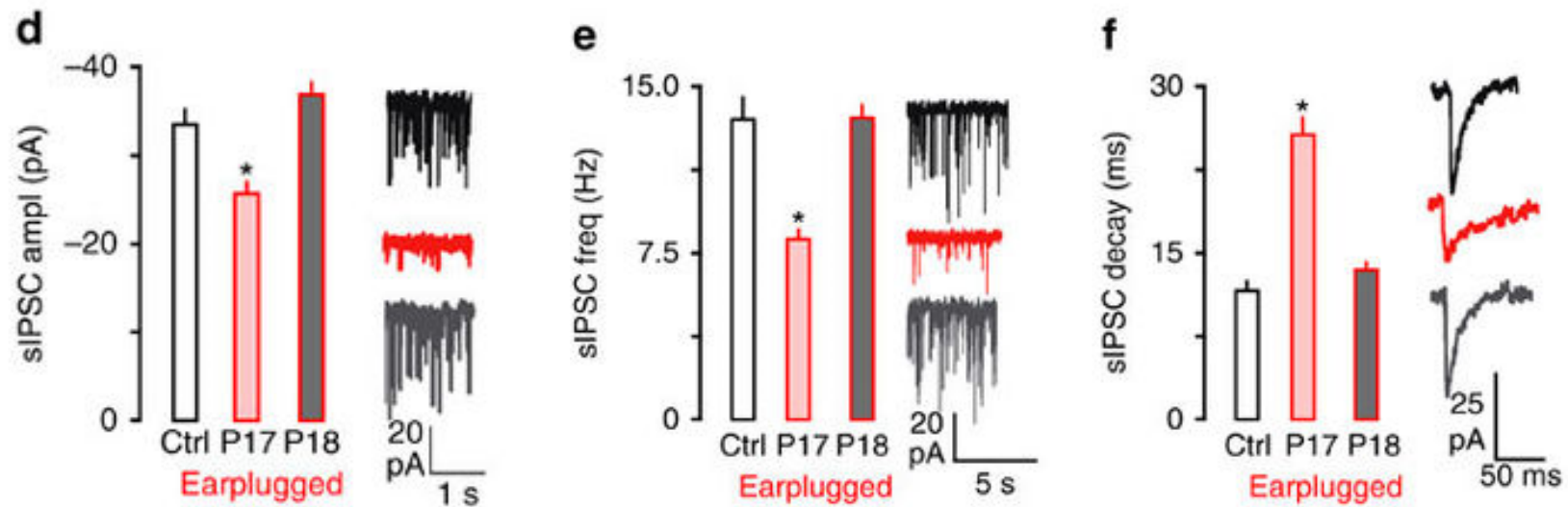


Figure 1 d, e, f



Early Visual Experience

- 4 groups

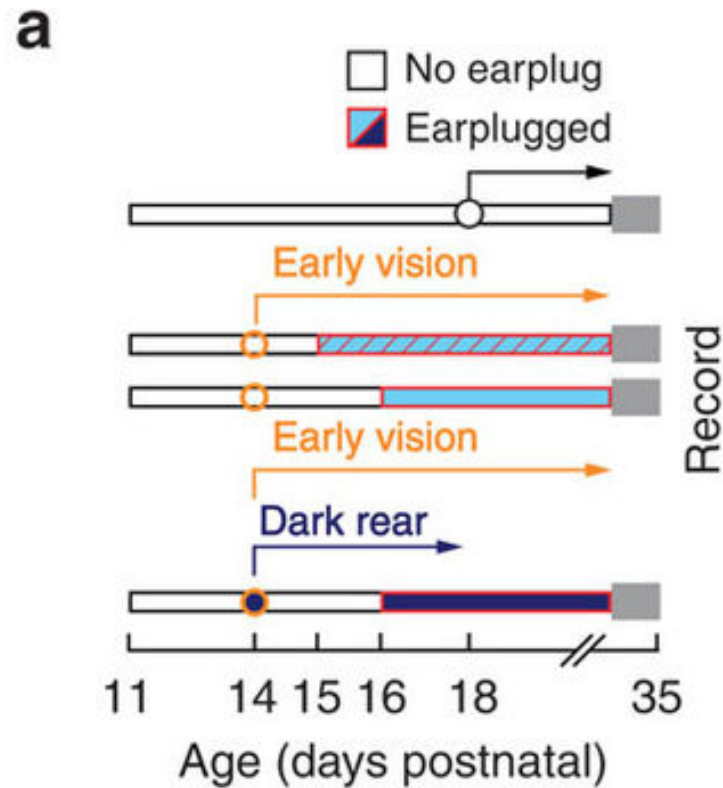
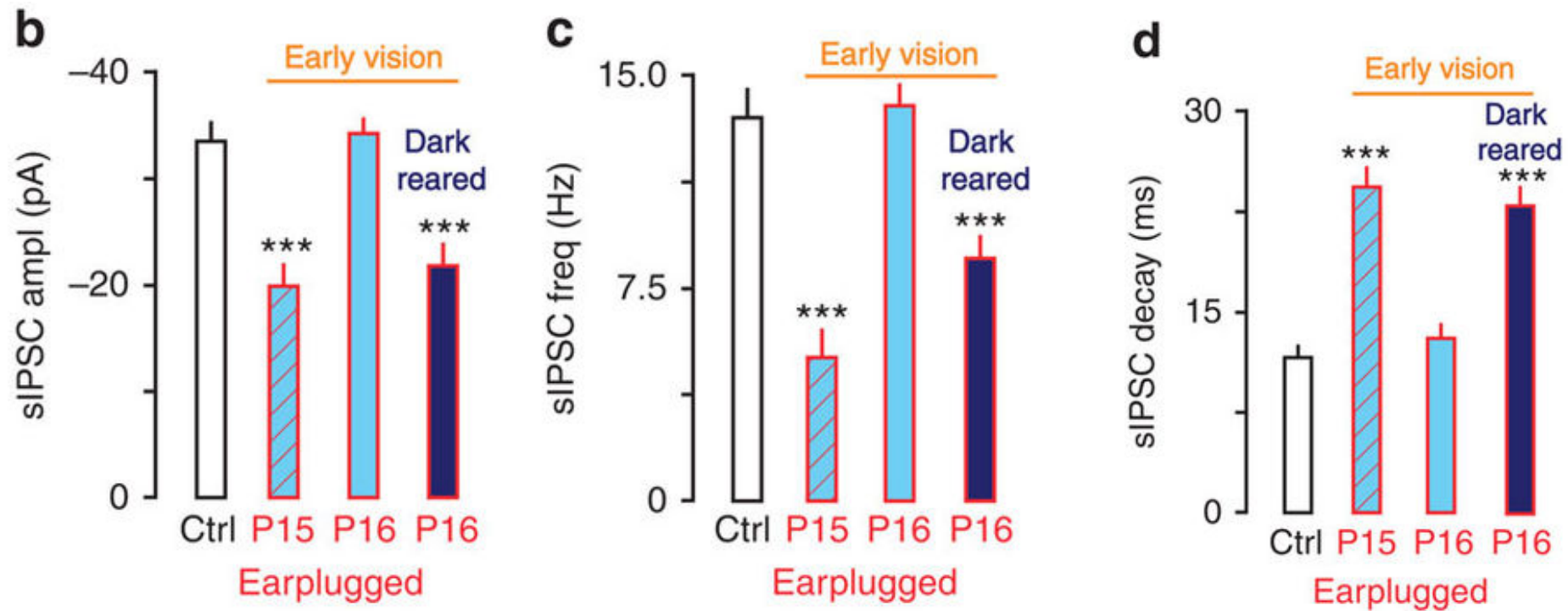


Figure 2



Delay Visual Experience

- 5 groups

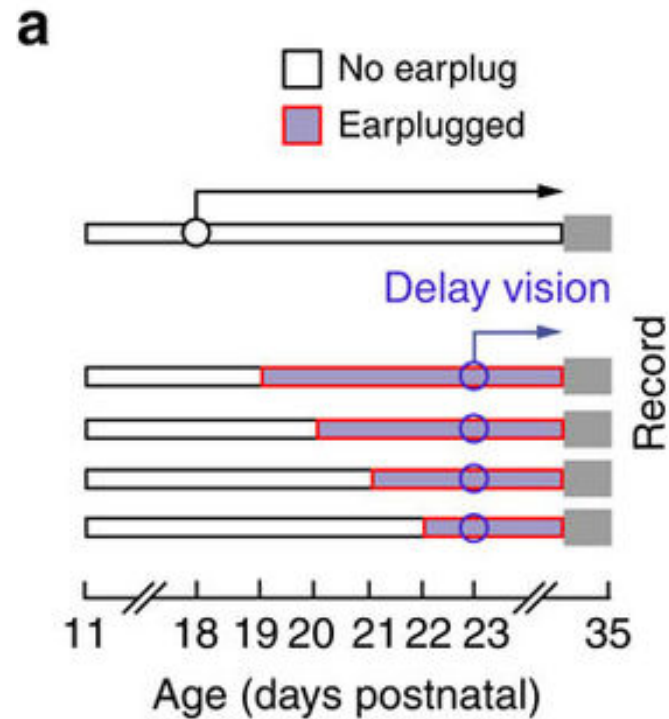
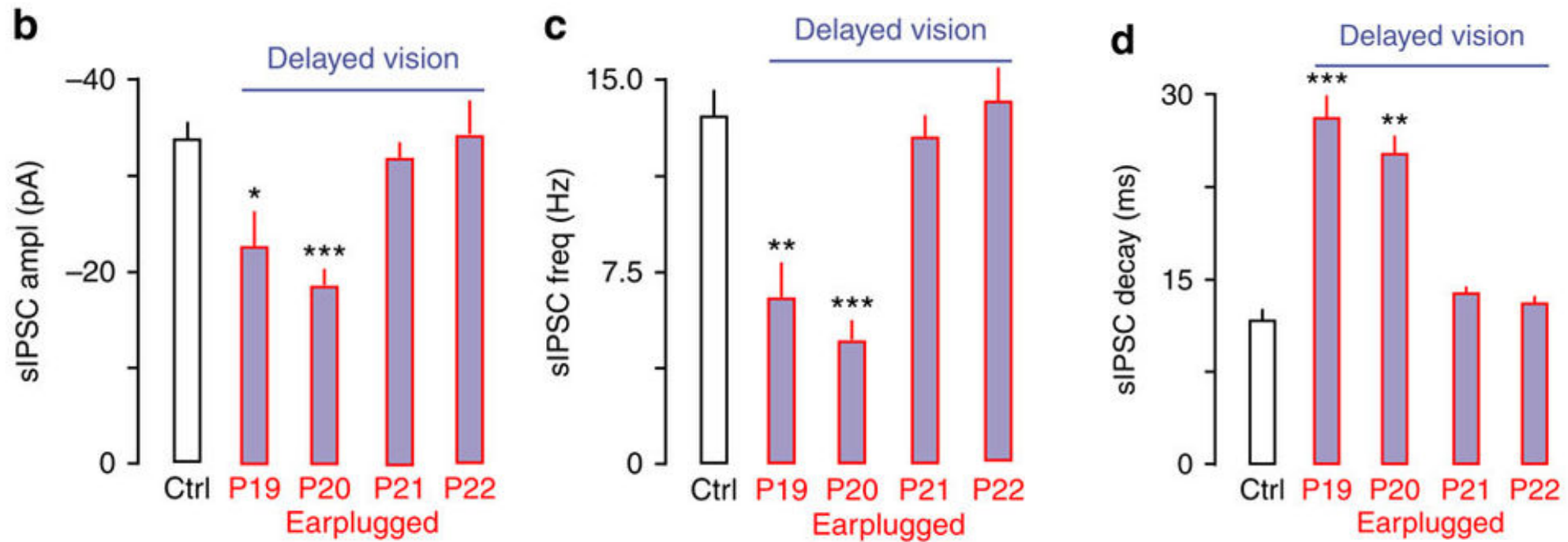


Figure 3



Vision Influences the Recovery From Hearing Loss

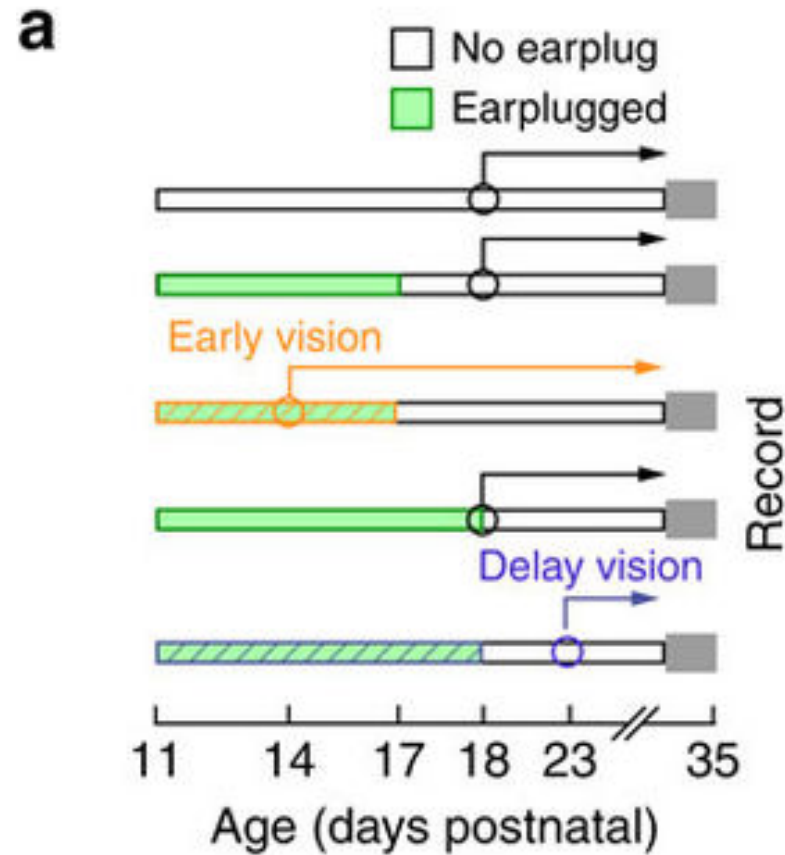
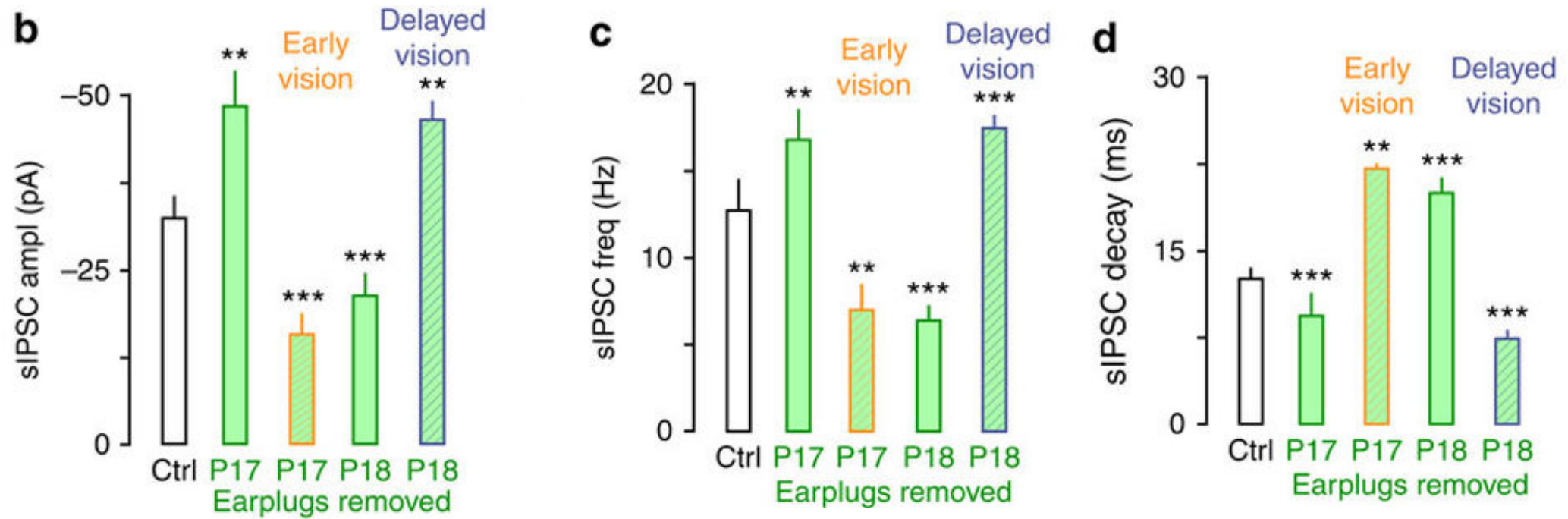


Figure 4



Vision Influences the Recovery From Hearing Loss (Pt. 2)

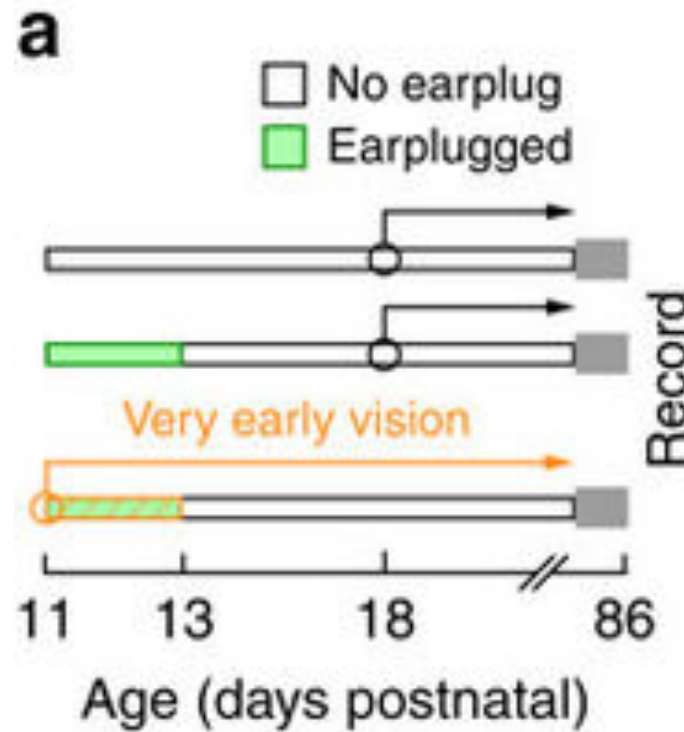
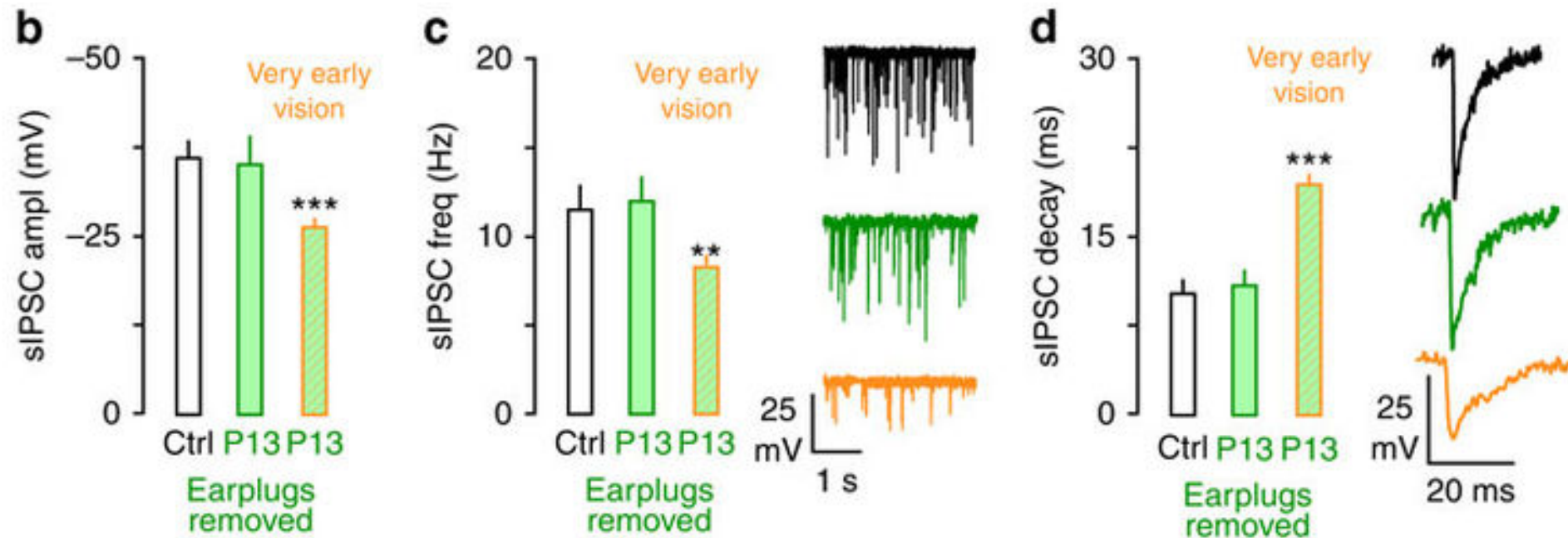
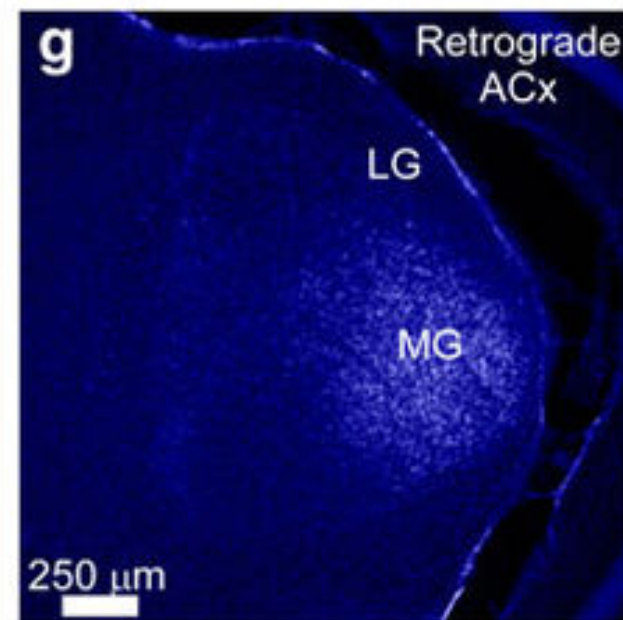
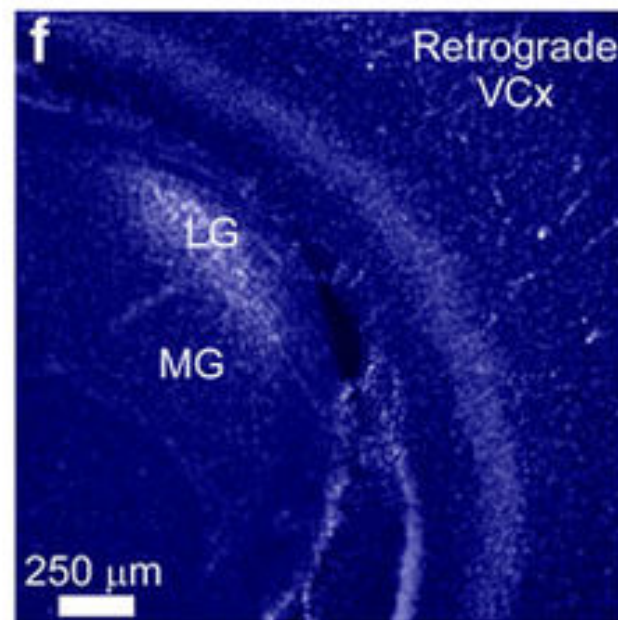


Figure 5





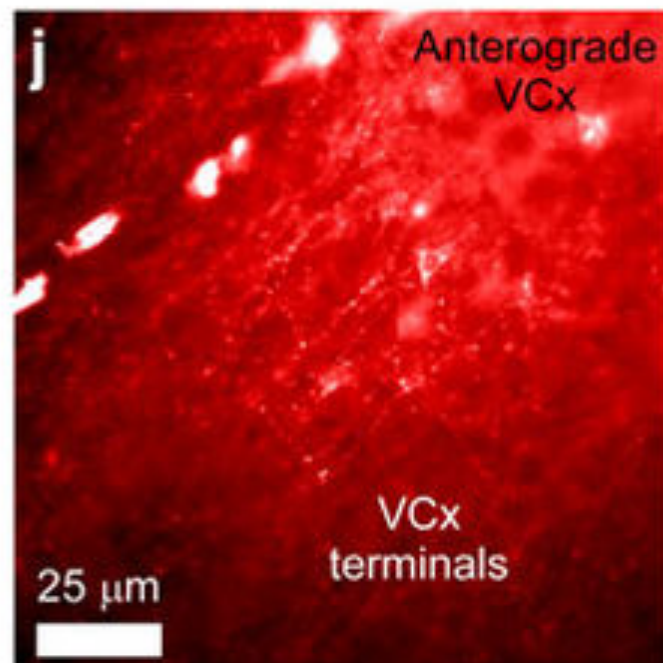
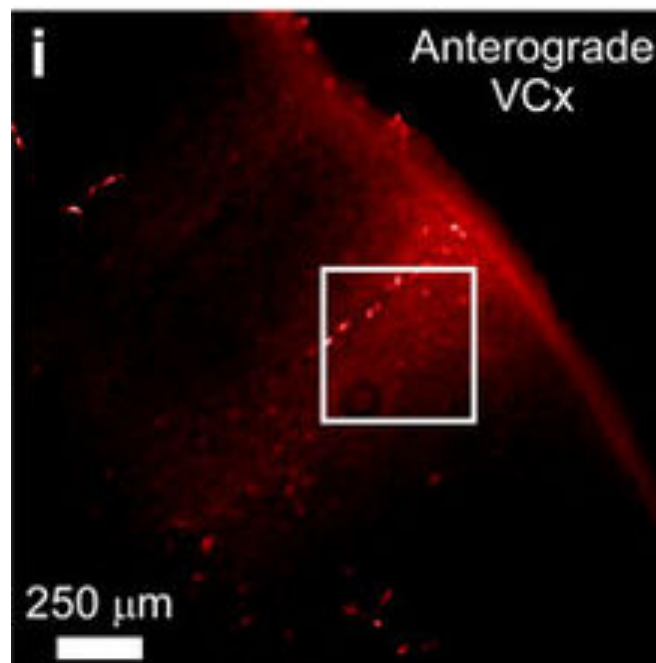
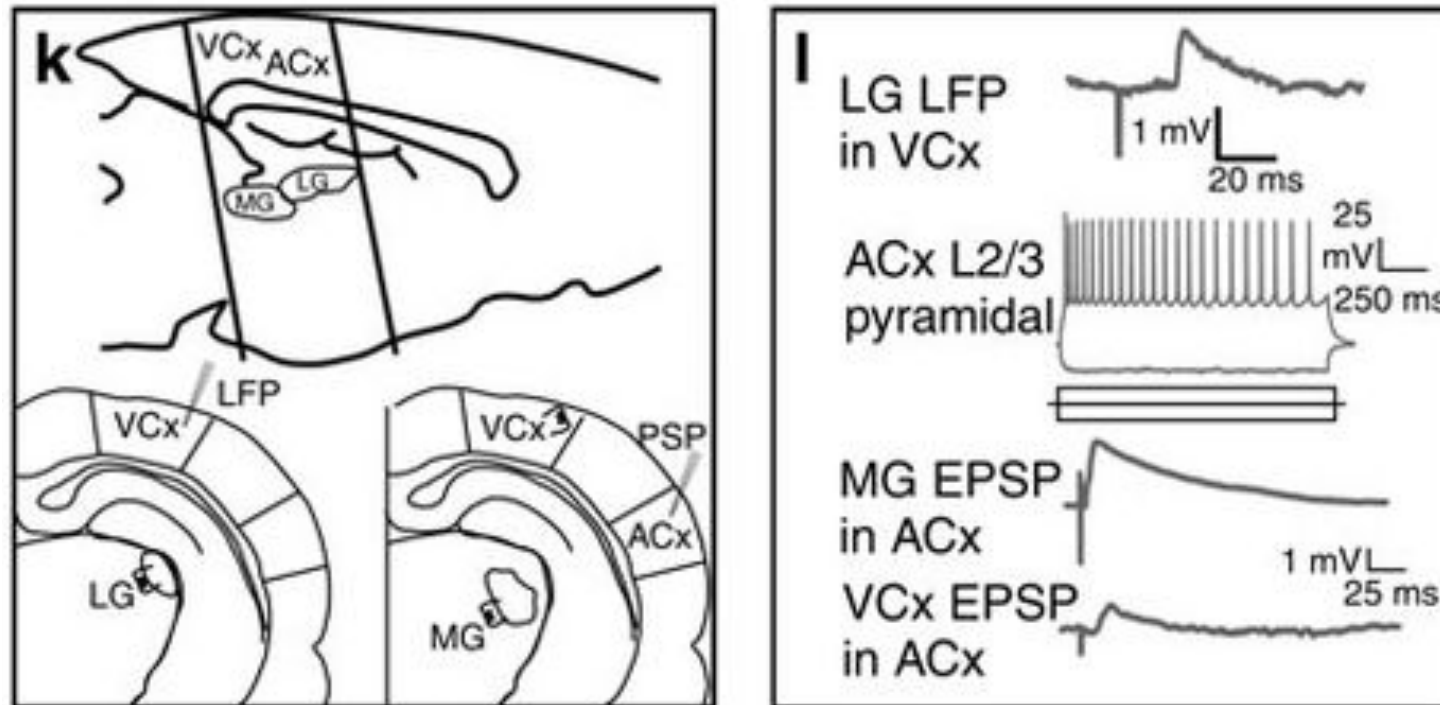


Figure 6l

- This is very confusing
 - What is that loop below ACx response?

Figure 6



Result

P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21	P22	P23	P35	P86	Result
							O								N
							O								W
							O								N
			O												W
			O												N
			●												W
												O			W
												O			W
												O			N
												O			N
							O								H
			O												W
							O								W
												O			H
							O								N
O															W

O	Eyelid open
●	Dark reared
	Earplugged
	Recording

	Normal sensitivity
	Weakened sensitivity
	Heightened sensitivity

Conclusion from current study

- “The ACx CPs closed precociously by early eyelid opening and extended by delayed eyelid opening.”
- Bidirectional effects in auditory system.
- It isn't necessarily true that having auditory experience just before eyelid opening will ensure normal sensitivity as trial 4 & 6 demonstrated.
- It isn't necessarily true that closing ACx CP early or late will weaken ACx neurons sensitivity.
- It isn't necessarily true that hearing loss will end ACx CP.
- ACx CP seems to end on its own regardless of vision on P21.

Conclusion (cont.)

- Brief normal auditory experience during end of critical period after transient hearing loss seems to heighten sensitivity
- In case of longer normal auditory experience during critical period after transient hearing loss- sensitivity approach baseline level.

Direction for Future Studies

- Examining balance between excitatory and inhibitory neurons in ACx with models.
- Testing cross-modality in other direction. If hearing loss is present during CPs, how will ACx neurons respond to visual stimulus? I wasn't sure if weaken sensitivity (membrane and synaptic properties) is specific to auditory stimulus (from MG) or applies to all.
- Testing VCx sensitivity (membrane and synaptic properties), I'm curious how does change in VCx sensitivity would parallel change in Acx sensitivity.
- Tracking change in ACx sensitivity over time DURING critical period (harder to implement).

Discussion questions

- What does experiment says about cross-modality plasticity?
- What does experiment says about auditory and visual experience during critical period?
- Why do you think they focus on IPSC?