TALK SESSION #1
JUNE 27 | 16-17.30 PM
EINSTEIN ROOM

Brain adaptation to sensory deprivation

Talk 1 - Computational hierarchy for tactile reading and speech processing in the occipital cortex of blind people

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The blind visual cortex responds to touch or sounds in a functionally specific fashion. However, the degree of retained cortical functionality is still debated. Here, we investigate the roles of the “visual” cortex of early blind and sighted people in reading and speech processing. Using fMRI we identified neuronal responses to words, pseudowords, and low-level sensory stimuli during reading and speech processing. While the blind early visual cortex (EVC) responded to linguistic and simple sensory stimuli, activity in the visual word form area (VWFA), was specific to linguistic information across modalities. Similar reading-specific activity in VWFA was observed in sighted subjects but only for visual reading and not for speech. Next, we used chronometric transcranial magnetic (chTMS) stimulation to causally trace the information flow between EVC and VWFA. We disrupted neuronal processing in the EVC and VWFA during reading and speech processing with 20Hz paired-pulse TMS in three distinct time windows (TW) from 60 to 260 ms after stimuli presentation. During reading, the involvement of the blind EVC precedes the one of VWFA but it also persists in the later TWs suggesting potential feedback mechanisms. These chTMS effects were remarkably similar to those of sighted controls who were reading printed material visually. TMS did not interfere with speech processing in any group at any temporal windows. These results suggest that the computational hierarchy of the visual cortex for reading is preserved in blind people reading Braille, and to a lower extent for speech processing.

Talk 2 - Visual experience is necessary for dissociation of responses to faces versus language in the fusiform

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Previous studies have found responses to both perceptual (e.g., face touching) and high-level (e.g., language) tasks in the visual cortices of blind people. Do these functions occupy the same or different parts of visual cortex? Congenitally blind (n=11) and sighted control (n=15) participants performed both face perception and language fMRI experiments. We tested functional specialization for faces and language in the ventral occipito-temporal cortex (VOTC) using individual-subject analyses. Blind participants touched 3D-printed models of faces and scenes and performed a 1-back task. The same participants performed reading and spoken language tasks with tactile Braille words, Braille consonant strings and tactile control shapes, spoken words and audio control (backwards speech). Sighted blindfolded controls (n=15) performed an analogous language task but with visual words and viewed line-drawings of faces and objects. In the blind group, we replicate the previously observed left-lateralized responses to tactile faces in lateral VOTC, at or near the classic fusiform face area (FFA). However, for blind people, face-responsive voxels (faces>scenes) in the VOTC also responded to written and spoken language (Braille/spoken words>control). By contrast the sighted showed a clear functional dissociation between VOTC responses to language and faces, whereby face responsive voxels did not show higher activity for written/spoken words than control conditions. Visual experience is not required for responses to tactile faces in left VOTC but is necessary for specialization for faces as opposed to language. An intriguing possibly is that connectivity to communication-relevant language regions together with visual experience leads to face/language dissociation in VOTC of sighted.

Talk 3 - Effects of experience on development of visual cortex: comparing sighted infants to blind and sighted

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Comparing adults with different sensory histories (blind vs. sighted) has uncovered effects of experience on human brain development. However, little is known about the developmental origins of experience-based plasticity in humans, since until recently all research has been done with adults. A key outstanding question is whether experience plays an instructive role in establishing functional signatures observed in typical development. Alternatively, the typical functional pattern might be present innately and reorganized by atypical sensory experience e.g., blindness. Here we dissociate instructive and reorganizing effects of experience by comparing the 'starting state' of visual cortex functional connectivity in two large cohorts of sighted infants (average age of 2 weeks, n=327, n=475 from dHCP) to those of blind (n=30) and blindfolded sighted (n=50) adults. Remarkably, we find that in secondary visual cortices the connectivity profile of infants resembles that of blind more than sighted adults: stronger connectivity with prefrontal than non-visual sensory networks (i.e., auditory, somatosensory). Visual experience appears to couple of visual cortex with other sensory-motor networks and de-couple visual from prefrontal cortices. Primary visual cortex (V1) shows a mixture of instructive and reorganizing effects, starting with equal frontal and sensory-motor connectivity at birth and diverging in opposite directions in sighted and blind adults. Finally, lateralization of occipital connectivity appears to be driven by blindness-related reorganization. These results dissociate instructive and reorganizing effect of experience on functional connectivity of human cortex and open new avenues for investigating the developmental origins of visual cortex function in humans.

Talk 4 - Altered grid-like coding in early blind people during imagined navigation

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Spatial Navigation in humans mostly relies on vision. However, the impact of early visual deprivation on the recruitment of the Human Navigation Network (HNN) and the creation of cognitive maps sustained by grid-cells in the Entorhinal Cortex (EC), is still yet unknown. Here, we tested blindfolded early blind (EB, 19) and sighted controls (SC, 19) individuals in both an fMRI imagined navigation and real-world navigation tasks. During the fMRI experiment participants were asked to imagine navigating within a clock-like environment going from one number to the other following auditory instructions (e.g., you are at 4 – go to 8). In the real-world navigation task, instead, blindfolded participants walked through different paths and were asked to estimate their distance and orientation compared to their starting point. Univariate analysis revealed that the two groups equally activated the HNN during clock navigation, demonstrating the resilience of this network to visual deprivation. However, hexadirectional coding analyses showed different neural geometries in the entorhinal cortex: six-fold (60˚) rotational symmetry, characteristic of grid-like coding, in SC and 4-Fold symmetry (90˚) in EB. Interestingly, higher parietal cortex activity during navigation, in the EB, was correlated with higher magnitude of 4-Fold symmetry as well as real-word navigation performance. Moreover, contrary to SC, EB's cognitive map was anchored to the main axis of the clock environment. In sum, early visual deprivation alters the neural geometry of entorhinal cognitive maps. Our results further suggest that this alteration may derive from EB's higher reliance on an egocentric reference frame during navigation.

Talk 5 - Activation of human visual area V6 during egocentric navigation with and without visual experience

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Introduction: V6 is a retinotopic area located in the dorsal visual stream that integrates eye movements with retinal and visuo-motor signal. Despite the known involvement of V6 in visual motion, it is still unknown whether it is involved in navigation and how sensory experiences shape its functional properties. We explored the involvement of V6 in egocentric navigation in sighted and in congenitally blind (CB) participants navigating via an in-house distance-to-sound sensory substitution device (SSD), the EyeCane.
Method: We performed two fMRI experiments on two independent datasets. In the first experiment, CB and sighted participants navigated the same mazes. The sighted performed the mazes via vision, while the CB via audition. The CB performed the mazes before and after a training session using the EyeCane SSD. In a second experiment a group of sighted people performed a motor topography task.
Results: Results show that right V6 (rhV6) is selectively involved in egocentric navigation independently by the sensory modality used. Indeed, after training rhV6 of CB is selectively recruited for auditory navigation like rhV6 of the sighted. Moreover, we found activation for body movement in area V6, that can putatively contribute to its involvement in egocentric navigation. Taken together, our findings suggest that area rhV6 is a unique hub that transforms spatially relevant sensory information into an egocentric representation for navigation. While vision is clearly the dominant modality, rhV6 is in fact a supramodal area that can develop its selectivity for navigation in the absence of visual experience during the critical period.

Talk 6 - Audiovisual Speech Integration in Cochlear Implant Users

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Speech is a rich multisensory stimulus that combines a dynamic stream of auditory information with visual cues arising from articulatory movements. In many situations, speech is fully intelligible based on auditory cues; however, the addition of visual speech cues results in significant gains in intelligibility when auditory cues are poorly resolved. The inverse effectiveness of visual cues has been well documented for speech presented in acoustic noise; however, less is known about the relative role of visual speech signals when auditory cues are degraded in other ways. Cochlear implants are a neural prosthesis capable of restoring a representation of sound to individuals with profound hearing loss. When provided very early in development, children with cochlear implants often go on to score similarly to their typically-hearing peers on tests of speech intelligibility by the time they are school-aged. However, the sound signal provided by a cochlear implant is of significantly poorer resolution than that provided by the intact cochlea. Here, we present data from two experiments that examined how auditory and visual speech cues affect perception in cochlear implant users compared to typically-hearing listeners. In the first, we examine how discordant cues are combined to generate illusory syllables (the McGurk effect) and discuss how similarities in behavioural performance may mask groupwise difference in thresholds for integration and sensory noise. In the second, we compare how these groups of listeners respond to temporal asynchrony between auditory and visual speech cues and discuss how differential weighting across modalities might affect listening strategies.