Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
Intramodal plasticity will be discussed in an animal model of congenital deafness (A. Kral) which shows a predominance of inhibitory interactions arising from the affected ear. This alteration in binaural integration is directly related to the observations of a loss of spatial abilities observed in UHL adults (P. Barone) whose magnitude of deficits is associated to the loss of cortical lateralization. All together these studies accounts for the constraints of delays in sequential cochlear implantation in congenitally deaf children (K. Gordon) in the restoration of spatial and binaural abilities. Concerning crossmodal plasticity, an animal model of early deafness (S. Lomber) will dissect how the access to auditory information during development determines visual compensation mechanisms and anatomical changes in the auditory system. Similarly, in humans we will show how visual crossmodal influences largely depend on the type of single or bilateral cochlear implantation (P. Sandmann) and how crossmodal reorganization can be reversed after rehabilitation through a cochlear implantation while improving neurocognitive functions (A Sharma). Thus, our symposium at the crossroads of basic and clinical research proposes complementary studies as a continuum in the understanding of the neural mechanisms involved in deafness rehabilitation during development and adulthood. It is targeting a wide audience of researchers in auditory neurosciences and psychophysics, but also it is directly addressed to clinicians and professionals in hearing rehabilitation.

Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cross-modal neuroplasticity refers to the recruitment and repurposing of neuronal resources of one sensory modality by another. In our studies on children and adults with deafness we find that auditory cortical areas are recruited and repurposed by both visual and somatosensory modalities providing evidence of cross-modal plasticity. Our studies show evidence of cross-modal plasticity from visual and somatosensory modalities in deaf children who are fitted with cochlear implants. Developmental cross-modal reorganization both visual and somatosensory modalities appears to be related to developmental maturity of the central auditory system and is predictive of speech perception performance with cochlear implants. In young deaf adults who receive implants at later ages in childhood, cortical auditory development is delayed well into adulthood and these individuals show evidence of cross-modal plasticity as a function of their developmental auditory cortical immaturity. Cross-modal recruitment is not limited to bilateral congenital deafness, we find evidence of cross-modal recruitment by vision and somatosensation in children with unilateral or single-sided deafness. Interestingly, cross-modal plasticity is not limited to the developing brain, as we see evidence of cross-modal re-organization from in adults with single-sided deafness. Frontal cortical involvement co-occurs with visual and somatosensory re-organization, suggestive of top-down modulation of cross-modal mechanisms. When individuals with single-sided deafness are fitted with cochlear implants, we see reversal of cross-modal plasticity corresponding with neurocognitive improvements. Overall, our research in humans suggests that cross-modal plasticity in deafness is a dynamic, versatile and reversible process, resulting from existing sub-threshold multisensory inputs to sensory cortices and top-down influences on inhibition, which adaptively interacts with the restoration of sensory deprivation.

Research Supported by NIH

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* Presenting Author

First Name	Last Name	Affiliation
Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Compared to hearing subjects, psychophysical studies have revealed specific superior visual abilities in the early-deaf, as well as enhanced auditory functions in the early-blind. The neural substrate for these superior sensory abilities has been identified to reside in the deprived cerebral cortices that have been reorganized by the remaining sensory modalities through crossmodal plasticity. Furthermore, the cartography of auditory cortex is altered following the loss of auditory input early in life. The current investigation examines how perinatal exposure to brief periods of acoustic stimulation alters the developmental trajectory of auditory cortex.

Compared to hearing animals, movement detection, localization of a flashed stimulus in the visual periphery, and face discrimination learning are superior in congenitally deaf cats. These enhanced functions are localized to specific regions of deaf auditory cortex. To examine the role of acoustic experience in mediating these enhanced visual functions in the deaf, hearing animals were chemically deafened with ototoxic drugs at increasing ages postnatal. The animals had one to sixteen weeks of acoustic experiences prior to deafness onset. In adulthood, the cats were trained and tested on the same visual tasks examined in the congenitally deaf cats. Overall, >9 weeks of acoustic experience resulted in no enhanced visual abilities. With >4 weeks of acoustic exposure, the enhanced motion detection ability was not evident. These reduced levels of enhanced visual functions are correlated with changes in cortical cartography. These results demonstrate that increasingly longer periods of perinatal acoustic experience result in reduced enhanced visual abilities and an increased size of auditory cortex.

This work was supported by the Canadian Institutes of Health Research.

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Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implants are the standard of care for children with bilateral deafness but are less readily adopted for children who have one deprived ear including those with single sided deafness (SSD). This discrepancy has several potential origins including a clinical notion that audibility in one ear is “good enough” and persists despite consistent reports of developmental delays in children with unilateral hearing loss. In this symposium talk, evidence of cortical reorganization measured by EEG in children who have unilateral deafness and/or asymmetric hearing will be presented. Effects of age as well as duration of unilateral deafness and/or asymmetric hearing on responses from auditory cortices and cortical connectivity will be discussed in context with implications for promoting binaural/spatial hearing through cochlear implantation.

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Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (review in Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex). The present study investigated the nature of binaural interactions with focus on excitation and inhibition.

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). In SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in ~60% of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare (< 2%). These data document the extraordinary extend of the reorganization of binaural interactions and demonstrate that the previously deaf ear causes inhibition of the responses to the hearing ear in

abnormally high proportion of units. That explains why after long periods of unilateral early deafness learning speech comprehension through the previously deaf ear is difficult and does not profit from what was learned through the other ear. Early binaural hearing is necessary in preventing these adverse consequences.

Supported by Deutsche Forschungsgemeinschaft (Exc 2177) and National Science Foundation in collaboration with BMBF (DLR # 01GQ1703), and MedEl Comp., Germany.

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Leonard	Schmidt	Dept. of Experimental Otology, Medical University Hannover
Jochen	Tillen	Dept. of Otolaryngology, J.W.Goethe University, Frankfurt am Main
Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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Pascale *	Sandmann *	University of Cologne

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Signature Pascale Sandmann

Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract A cortical lateralization is a functional organization observed in most sensory modalities and in the auditory domain, the functional lateralization is devolved to spatial hearing, with each hemisphere primarily involved in processing the localization of sound in contralateral space. The representation of the contralateral auditory field is underpinned by contralateral aural dominance which results from complex neural interactions between inputs from each ear. We showed (Vannson et al 2020) that unilateral hearing loss (UHL) induces deficits in binaural integration (spatial localization and speech understanding in noise) but also reverses contralateral aural dominance in favor of the preserved ipsilateral ear. The extent of this brain reorganization is directly correlated to the extent of spatial behavioral deficit. A second study (Karoui et al 2022) in a group of UHL patients treated with a cochlear implant demonstrated that restoration of auditory inputs to the deaf ear through electrical stimulation restored contralateral hemispheric dominance of both the better and impaired ear. Finally, mirroring what was observed in UHL patients, the extent of restoration of contralateral dominance was directly correlated with the ability to localize sounds after implantation. Lastly in a 3rd group of UHL patients we observed clearly a subgroup of subjects with near normal sound localization performances and a near normal spatial Mismatch Negativity (MMN) a neural marker of spatial abilities. This suggest the existence of behavioral adaptive linked to adaptive brain compensation.
Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Pascal *	Barone *	CNRS UMR5549
Mathieu	Marx	Service d’Otologie, Otoneurologie et ORL pédiatrique, CHU Toulouse Purpan, France

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Signature Pascal Barone

Brain Plasticity in Deafness

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Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
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Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Research Supported by NIH

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Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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This work was supported by the Canadian Institutes of Health Research.

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* Presenting Author

First Name	Last Name	Affiliation
Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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First Name	Last Name	Affiliation
Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (review in Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex). The present study investigated the nature of binaural interactions with focus on excitation and inhibition.

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). In SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in ~60% of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare (< 2%). These data document the extraordinary extend of the reorganization of binaural interactions and demonstrate that the previously deaf ear causes inhibition of the responses to the hearing ear in

abnormally high proportion of units. That explains why after long periods of unilateral early deafness learning speech comprehension through the previously deaf ear is difficult and does not profit from what was learned through the other ear. Early binaural hearing is necessary in preventing these adverse consequences.

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Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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* Presenting Author

First Name	Last Name	Affiliation
Pascale *	Sandmann *	University of Cologne

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Signature Pascale Sandmann

Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract A cortical lateralization is a functional organization observed in most sensory modalities and in the auditory domain, the functional lateralization is devolved to spatial hearing, with each hemisphere primarily involved in processing the localization of sound in contralateral space. The representation of the contralateral auditory field is underpinned by contralateral aural dominance which results from complex neural interactions between inputs from each ear. We showed (Vannson et al 2020) that unilateral hearing loss (UHL) induces deficits in binaural integration (spatial localization and speech understanding in noise) but also reverses contralateral aural dominance in favor of the preserved ipsilateral ear. The extent of this brain reorganization is directly correlated to the extent of spatial behavioral deficit. A second study (Karoui et al 2022) in a group of UHL patients treated with a cochlear implant demonstrated that restoration of auditory inputs to the deaf ear through electrical stimulation restored contralateral hemispheric dominance of both the better and impaired ear. Finally, mirroring what was observed in UHL patients, the extent of restoration of contralateral dominance was directly correlated with the ability to localize sounds after implantation. Lastly in a 3rd group of UHL patients we observed clearly a subgroup of subjects with near normal sound localization performances and a near normal spatial Mismatch Negativity (MMN) a neural marker of spatial abilities. This suggest the existence of behavioral adaptive linked to adaptive brain compensation.
Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Pascal *	Barone *	CNRS UMR5549
Mathieu	Marx	Service d’Otologie, Otoneurologie et ORL pédiatrique, CHU Toulouse Purpan, France

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Signature Pascal Barone

Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
Intramodal plasticity will be discussed in an animal model of congenital deafness (A. Kral) which shows a predominance of inhibitory interactions arising from the affected ear. This alteration in binaural integration is directly related to the observations of a loss of spatial abilities observed in UHL adults (P. Barone) whose magnitude of deficits is associated to the loss of cortical lateralization. All together these studies accounts for the constraints of delays in sequential cochlear implantation in congenitally deaf children (K. Gordon) in the restoration of spatial and binaural abilities. Concerning crossmodal plasticity, an animal model of early deafness (S. Lomber) will dissect how the access to auditory information during development determines visual compensation mechanisms and anatomical changes in the auditory system. Similarly, in humans we will show how visual crossmodal influences largely depend on the type of single or bilateral cochlear implantation (P. Sandmann) and how crossmodal reorganization can be reversed after rehabilitation through a cochlear implantation while improving neurocognitive functions (A Sharma). Thus, our symposium at the crossroads of basic and clinical research proposes complementary studies as a continuum in the understanding of the neural mechanisms involved in deafness rehabilitation during development and adulthood. It is targeting a wide audience of researchers in auditory neurosciences and psychophysics, but also it is directly addressed to clinicians and professionals in hearing rehabilitation.

Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cross-modal neuroplasticity refers to the recruitment and repurposing of neuronal resources of one sensory modality by another. In our studies on children and adults with deafness we find that auditory cortical areas are recruited and repurposed by both visual and somatosensory modalities providing evidence of cross-modal plasticity. Our studies show evidence of cross-modal plasticity from visual and somatosensory modalities in deaf children who are fitted with cochlear implants. Developmental cross-modal reorganization both visual and somatosensory modalities appears to be related to developmental maturity of the central auditory system and is predictive of speech perception performance with cochlear implants. In young deaf adults who receive implants at later ages in childhood, cortical auditory development is delayed well into adulthood and these individuals show evidence of cross-modal plasticity as a function of their developmental auditory cortical immaturity. Cross-modal recruitment is not limited to bilateral congenital deafness, we find evidence of cross-modal recruitment by vision and somatosensation in children with unilateral or single-sided deafness. Interestingly, cross-modal plasticity is not limited to the developing brain, as we see evidence of cross-modal re-organization from in adults with single-sided deafness. Frontal cortical involvement co-occurs with visual and somatosensory re-organization, suggestive of top-down modulation of cross-modal mechanisms. When individuals with single-sided deafness are fitted with cochlear implants, we see reversal of cross-modal plasticity corresponding with neurocognitive improvements. Overall, our research in humans suggests that cross-modal plasticity in deafness is a dynamic, versatile and reversible process, resulting from existing sub-threshold multisensory inputs to sensory cortices and top-down influences on inhibition, which adaptively interacts with the restoration of sensory deprivation.

Research Supported by NIH

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First Name	Last Name	Affiliation
Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Compared to hearing subjects, psychophysical studies have revealed specific superior visual abilities in the early-deaf, as well as enhanced auditory functions in the early-blind. The neural substrate for these superior sensory abilities has been identified to reside in the deprived cerebral cortices that have been reorganized by the remaining sensory modalities through crossmodal plasticity. Furthermore, the cartography of auditory cortex is altered following the loss of auditory input early in life. The current investigation examines how perinatal exposure to brief periods of acoustic stimulation alters the developmental trajectory of auditory cortex.

Compared to hearing animals, movement detection, localization of a flashed stimulus in the visual periphery, and face discrimination learning are superior in congenitally deaf cats. These enhanced functions are localized to specific regions of deaf auditory cortex. To examine the role of acoustic experience in mediating these enhanced visual functions in the deaf, hearing animals were chemically deafened with ototoxic drugs at increasing ages postnatal. The animals had one to sixteen weeks of acoustic experiences prior to deafness onset. In adulthood, the cats were trained and tested on the same visual tasks examined in the congenitally deaf cats. Overall, >9 weeks of acoustic experience resulted in no enhanced visual abilities. With >4 weeks of acoustic exposure, the enhanced motion detection ability was not evident. These reduced levels of enhanced visual functions are correlated with changes in cortical cartography. These results demonstrate that increasingly longer periods of perinatal acoustic experience result in reduced enhanced visual abilities and an increased size of auditory cortex.

This work was supported by the Canadian Institutes of Health Research.

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Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implants are the standard of care for children with bilateral deafness but are less readily adopted for children who have one deprived ear including those with single sided deafness (SSD). This discrepancy has several potential origins including a clinical notion that audibility in one ear is “good enough” and persists despite consistent reports of developmental delays in children with unilateral hearing loss. In this symposium talk, evidence of cortical reorganization measured by EEG in children who have unilateral deafness and/or asymmetric hearing will be presented. Effects of age as well as duration of unilateral deafness and/or asymmetric hearing on responses from auditory cortices and cortical connectivity will be discussed in context with implications for promoting binaural/spatial hearing through cochlear implantation.

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Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (review in Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex). The present study investigated the nature of binaural interactions with focus on excitation and inhibition.

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). In SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in ~60% of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare (< 2%). These data document the extraordinary extend of the reorganization of binaural interactions and demonstrate that the previously deaf ear causes inhibition of the responses to the hearing ear in

abnormally high proportion of units. That explains why after long periods of unilateral early deafness learning speech comprehension through the previously deaf ear is difficult and does not profit from what was learned through the other ear. Early binaural hearing is necessary in preventing these adverse consequences.

Supported by Deutsche Forschungsgemeinschaft (Exc 2177) and National Science Foundation in collaboration with BMBF (DLR # 01GQ1703), and MedEl Comp., Germany.

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Leonard	Schmidt	Dept. of Experimental Otology, Medical University Hannover
Jochen	Tillen	Dept. of Otolaryngology, J.W.Goethe University, Frankfurt am Main
Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Pascale *	Sandmann *	University of Cologne

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Signature Pascale Sandmann

Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

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Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Pascal *	Barone *	CNRS UMR5549
Mathieu	Marx	Service d’Otologie, Otoneurologie et ORL pédiatrique, CHU Toulouse Purpan, France

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Signature Pascal Barone

Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
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Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Research Supported by NIH

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Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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This work was supported by the Canadian Institutes of Health Research.

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Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a "minimal" Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implants are the standard of care for children with bilateral deafness but are less readily adopted for children who have one deprived ear including those with single sided deafness (SSD). This discrepancy has several potential origins including a clinical notion that audibility in one ear is "good enough" and persists despite consistent reports of developmental delays in children with unilateral hearing loss. In this symposium talk, evidence of cortical reorganization measured by EEG in children who have unilateral deafness and/or asymmetric hearing will be presented. Effects of age as well as duration of unilateral deafness and/or asymmetric hearing on responses from auditory cortices and cortical connectivity will be discussed in context with implications for promoting binaural/spatial hearing through cochlear implantation.

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First Name	Last Name	Affiliation
Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (review in Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex). The present study investigated the nature of binaural interactions with focus on excitation and inhibition.

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). In SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in ~60% of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare (< 2%). These data document the extraordinary extend of the reorganization of binaural interactions and demonstrate that the previously deaf ear causes inhibition of the responses to the hearing ear in

abnormally high proportion of units. That explains why after long periods of unilateral early deafness learning speech comprehension through the previously deaf ear is difficult and does not profit from what was learned through the other ear. Early binaural hearing is necessary in preventing these adverse consequences.

Supported by Deutsche Forschungsgemeinschaft (Exc 2177) and National Science Foundation in collaboration with BMBF (DLR # 01GQ1703), and MedEl Comp., Germany.

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First Name	Last Name	Affiliation
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Leonard	Schmidt	Dept. of Experimental Otology, Medical University Hannover
Jochen	Tillen	Dept. of Otolaryngology, J.W.Goethe University, Frankfurt am Main
Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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* Presenting Author

First Name	Last Name	Affiliation
Pascale *	Sandmann *	University of Cologne

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Signature Pascale Sandmann

Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract A cortical lateralization is a functional organization observed in most sensory modalities and in the auditory domain, the functional lateralization is devolved to spatial hearing, with each hemisphere primarily involved in processing the localization of sound in contralateral space. The representation of the contralateral auditory field is underpinned by contralateral aural dominance which results from complex neural interactions between inputs from each ear. We showed (Vannson et al 2020) that unilateral hearing loss (UHL) induces deficits in binaural integration (spatial localization and speech understanding in noise) but also reverses contralateral aural dominance in favor of the preserved ipsilateral ear. The extent of this brain reorganization is directly correlated to the extent of spatial behavioral deficit. A second study (Karoui et al 2022) in a group of UHL patients treated with a cochlear implant demonstrated that restoration of auditory inputs to the deaf ear through electrical stimulation restored contralateral hemispheric dominance of both the better and impaired ear. Finally, mirroring what was observed in UHL patients, the extent of restoration of contralateral dominance was directly correlated with the ability to localize sounds after implantation. Lastly in a 3rd group of UHL patients we observed clearly a subgroup of subjects with near normal sound localization performances and a near normal spatial Mismatch Negativity (MMN) a neural marker of spatial abilities. This suggest the existence of behavioral adaptive linked to adaptive brain compensation.
Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Mathieu	Marx	Service d’Otologie, Otoneurologie et ORL pédiatrique, CHU Toulouse Purpan, France

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Signature Pascal Barone

Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
Intramodal plasticity will be discussed in an animal model of congenital deafness (A. Kral) which shows a predominance of inhibitory interactions arising from the affected ear. This alteration in binaural integration is directly related to the observations of a loss of spatial abilities observed in UHL adults (P. Barone) whose magnitude of deficits is associated to the loss of cortical lateralization. All together these studies accounts for the constraints of delays in sequential cochlear implantation in congenitally deaf children (K. Gordon) in the restoration of spatial and binaural abilities. Concerning crossmodal plasticity, an animal model of early deafness (S. Lomber) will dissect how the access to auditory information during development determines visual compensation mechanisms and anatomical changes in the auditory system. Similarly, in humans we will show how visual crossmodal influences largely depend on the type of single or bilateral cochlear implantation (P. Sandmann) and how crossmodal reorganization can be reversed after rehabilitation through a cochlear implantation while improving neurocognitive functions (A Sharma). Thus, our symposium at the crossroads of basic and clinical research proposes complementary studies as a continuum in the understanding of the neural mechanisms involved in deafness rehabilitation during development and adulthood. It is targeting a wide audience of researchers in auditory neurosciences and psychophysics, but also it is directly addressed to clinicians and professionals in hearing rehabilitation.

Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cross-modal neuroplasticity refers to the recruitment and repurposing of neuronal resources of one sensory modality by another. In our studies on children and adults with deafness we find that auditory cortical areas are recruited and repurposed by both visual and somatosensory modalities providing evidence of cross-modal plasticity. Our studies show evidence of cross-modal plasticity from visual and somatosensory modalities in deaf children who are fitted with cochlear implants. Developmental cross-modal reorganization both visual and somatosensory modalities appears to be related to developmental maturity of the central auditory system and is predictive of speech perception performance with cochlear implants. In young deaf adults who receive implants at later ages in childhood, cortical auditory development is delayed well into adulthood and these individuals show evidence of cross-modal plasticity as a function of their developmental auditory cortical immaturity. Cross-modal recruitment is not limited to bilateral congenital deafness, we find evidence of cross-modal recruitment by vision and somatosensation in children with unilateral or single-sided deafness. Interestingly, cross-modal plasticity is not limited to the developing brain, as we see evidence of cross-modal re-organization from in adults with single-sided deafness. Frontal cortical involvement co-occurs with visual and somatosensory re-organization, suggestive of top-down modulation of cross-modal mechanisms. When individuals with single-sided deafness are fitted with cochlear implants, we see reversal of cross-modal plasticity corresponding with neurocognitive improvements. Overall, our research in humans suggests that cross-modal plasticity in deafness is a dynamic, versatile and reversible process, resulting from existing sub-threshold multisensory inputs to sensory cortices and top-down influences on inhibition, which adaptively interacts with the restoration of sensory deprivation.

Research Supported by NIH

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Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Compared to hearing subjects, psychophysical studies have revealed specific superior visual abilities in the early-deaf, as well as enhanced auditory functions in the early-blind. The neural substrate for these superior sensory abilities has been identified to reside in the deprived cerebral cortices that have been reorganized by the remaining sensory modalities through crossmodal plasticity. Furthermore, the cartography of auditory cortex is altered following the loss of auditory input early in life. The current investigation examines how perinatal exposure to brief periods of acoustic stimulation alters the developmental trajectory of auditory cortex.

Compared to hearing animals, movement detection, localization of a flashed stimulus in the visual periphery, and face discrimination learning are superior in congenitally deaf cats. These enhanced functions are localized to specific regions of deaf auditory cortex. To examine the role of acoustic experience in mediating these enhanced visual functions in the deaf, hearing animals were chemically deafened with ototoxic drugs at increasing ages postnatal. The animals had one to sixteen weeks of acoustic experiences prior to deafness onset. In adulthood, the cats were trained and tested on the same visual tasks examined in the congenitally deaf cats. Overall, >9 weeks of acoustic experience resulted in no enhanced visual abilities. With >4 weeks of acoustic exposure, the enhanced motion detection ability was not evident. These reduced levels of enhanced visual functions are correlated with changes in cortical cartography. These results demonstrate that increasingly longer periods of perinatal acoustic experience result in reduced enhanced visual abilities and an increased size of auditory cortex.

This work was supported by the Canadian Institutes of Health Research.

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Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

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Jochen	Tillen	Dept. of Otolaryngology, J.W.Goethe University, Frankfurt am Main
Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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Pascale *	Sandmann *	University of Cologne

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Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

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Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Signature Pascal Barone

Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Session Description The symposium is aimed on the mechanisms of brain plasticity after hearing loss and their primordial role in the success of rehabilitation by neuroprosthesis. The symposium will address the mechanisms of intra- and crossmodal brain plasticity in a multidimensional approach, from animal models to the patient with a life-time perspective. The investigation will offer a multi-scale standpoint from single cell recording to functional connectivity with a specific aim to link adaptive behavior to brain reorganization.
Intramodal plasticity will be discussed in an animal model of congenital deafness (A. Kral) which shows a predominance of inhibitory interactions arising from the affected ear. This alteration in binaural integration is directly related to the observations of a loss of spatial abilities observed in UHL adults (P. Barone) whose magnitude of deficits is associated to the loss of cortical lateralization. All together these studies accounts for the constraints of delays in sequential cochlear implantation in congenitally deaf children (K. Gordon) in the restoration of spatial and binaural abilities. Concerning crossmodal plasticity, an animal model of early deafness (S. Lomber) will dissect how the access to auditory information during development determines visual compensation mechanisms and anatomical changes in the auditory system. Similarly, in humans we will show how visual crossmodal influences largely depend on the type of single or bilateral cochlear implantation (P. Sandmann) and how crossmodal reorganization can be reversed after rehabilitation through a cochlear implantation while improving neurocognitive functions (A Sharma). Thus, our symposium at the crossroads of basic and clinical research proposes complementary studies as a continuum in the understanding of the neural mechanisms involved in deafness rehabilitation during development and adulthood. It is targeting a wide audience of researchers in auditory neurosciences and psychophysics, but also it is directly addressed to clinicians and professionals in hearing rehabilitation.

Presenter Diversity The symposium is gender (50% women) and geographically balanced (50% Europe/50% North America) including one junior female PI

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cross-modal neuroplasticity refers to the recruitment and repurposing of neuronal resources of one sensory modality by another. In our studies on children and adults with deafness we find that auditory cortical areas are recruited and repurposed by both visual and somatosensory modalities providing evidence of cross-modal plasticity. Our studies show evidence of cross-modal plasticity from visual and somatosensory modalities in deaf children who are fitted with cochlear implants. Developmental cross-modal reorganization both visual and somatosensory modalities appears to be related to developmental maturity of the central auditory system and is predictive of speech perception performance with cochlear implants. In young deaf adults who receive implants at later ages in childhood, cortical auditory development is delayed well into adulthood and these individuals show evidence of cross-modal plasticity as a function of their developmental auditory cortical immaturity. Cross-modal recruitment is not limited to bilateral congenital deafness, we find evidence of cross-modal recruitment by vision and somatosensation in children with unilateral or single-sided deafness. Interestingly, cross-modal plasticity is not limited to the developing brain, as we see evidence of cross-modal re-organization from in adults with single-sided deafness. Frontal cortical involvement co-occurs with visual and somatosensory re-organization, suggestive of top-down modulation of cross-modal mechanisms. When individuals with single-sided deafness are fitted with cochlear implants, we see reversal of cross-modal plasticity corresponding with neurocognitive improvements. Overall, our research in humans suggests that cross-modal plasticity in deafness is a dynamic, versatile and reversible process, resulting from existing sub-threshold multisensory inputs to sensory cortices and top-down influences on inhibition, which adaptively interacts with the restoration of sensory deprivation.

Research Supported by NIH

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* Presenting Author

First Name	Last Name	Affiliation
Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Compared to hearing subjects, psychophysical studies have revealed specific superior visual abilities in the early-deaf, as well as enhanced auditory functions in the early-blind. The neural substrate for these superior sensory abilities has been identified to reside in the deprived cerebral cortices that have been reorganized by the remaining sensory modalities through crossmodal plasticity. Furthermore, the cartography of auditory cortex is altered following the loss of auditory input early in life. The current investigation examines how perinatal exposure to brief periods of acoustic stimulation alters the developmental trajectory of auditory cortex.

Compared to hearing animals, movement detection, localization of a flashed stimulus in the visual periphery, and face discrimination learning are superior in congenitally deaf cats. These enhanced functions are localized to specific regions of deaf auditory cortex. To examine the role of acoustic experience in mediating these enhanced visual functions in the deaf, hearing animals were chemically deafened with ototoxic drugs at increasing ages postnatal. The animals had one to sixteen weeks of acoustic experiences prior to deafness onset. In adulthood, the cats were trained and tested on the same visual tasks examined in the congenitally deaf cats. Overall, >9 weeks of acoustic experience resulted in no enhanced visual abilities. With >4 weeks of acoustic exposure, the enhanced motion detection ability was not evident. These reduced levels of enhanced visual functions are correlated with changes in cortical cartography. These results demonstrate that increasingly longer periods of perinatal acoustic experience result in reduced enhanced visual abilities and an increased size of auditory cortex.

This work was supported by the Canadian Institutes of Health Research.

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Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implants are the standard of care for children with bilateral deafness but are less readily adopted for children who have one deprived ear including those with single sided deafness (SSD). This discrepancy has several potential origins including a clinical notion that audibility in one ear is “good enough” and persists despite consistent reports of developmental delays in children with unilateral hearing loss. In this symposium talk, evidence of cortical reorganization measured by EEG in children who have unilateral deafness and/or asymmetric hearing will be presented. Effects of age as well as duration of unilateral deafness and/or asymmetric hearing on responses from auditory cortices and cortical connectivity will be discussed in context with implications for promoting binaural/spatial hearing through cochlear implantation.

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Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Performance of sequential cochlear implantations in prelingually deaf children shows that the second implanted ear underperforms in speech comprehension (review in Gordon and Kral, 2019, Hear Res). An inhibition between the ears in such condition has been suggested (Burdo et al., 2016, Eur Ann ORL), but the physiological mechanism remained elusive. In cats with single-sided congenital deafness (SSD) the aural preference shifted towards the hearing ear on both hemispheres (Kral et al., 2013, Brain). Binaural integration was also compromised (Tillein et al., 2016 Cereb Cortex). The present study investigated the nature of binaural interactions with focus on excitation and inhibition.

In the present study, 9 adult hearing controls (HCs), 9 adult bilaterally congenitally deaf cats (CDC) and 2 adult SSD cats were used. All animals were acutely electrically stimulated by cochlear implants (CI). Cortical responses were evoked by a train of 3 biphasic electric pulses (200 µs/phase, 500 Hz). Intensities up to 12 dB above auditory brainstem response threshold were used, whereas the contralateral ear was kept constant at 6 dB above threshold, and the current level of the ipsilateral ear was varied from -2 to 12 dB above threshold. Multiunit activity was recorded using 16-channels arrays covering all layers of the primary auditory cortex. Responses were classified to excitation or inhibition depending on whether the stimulation at the ipsilateral ear significantly increased or reduced the firing rate with increasing level.

In HCs, the ipsilateral ear induced inhibition of the responses to the contralateral ear in ~40% of recording sites, whereas in CDCs this proportion was smaller (~30%). In SSD animals, the deaf ear consistently induced suppression of the responses to the hearing ear in ~60% of units, whereas vice versa the hearing ear caused excitation and inhibition was exceptionally rare (< 2%). These data document the extraordinary extend of the reorganization of binaural interactions and demonstrate that the previously deaf ear causes inhibition of the responses to the hearing ear in

abnormally high proportion of units. That explains why after long periods of unilateral early deafness learning speech comprehension through the previously deaf ear is difficult and does not profit from what was learned through the other ear. Early binaural hearing is necessary in preventing these adverse consequences.

Supported by Deutsche Forschungsgemeinschaft (Exc 2177) and National Science Foundation in collaboration with BMBF (DLR # 01GQ1703), and MedEl Comp., Germany.

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Leonard	Schmidt	Dept. of Experimental Otology, Medical University Hannover
Jochen	Tillen	Dept. of Otolaryngology, J.W.Goethe University, Frankfurt am Main
Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

Affiliation University of Cologne

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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Pascale *	Sandmann *	University of Cologne

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Signature Pascale Sandmann

Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

Individual Abstract A cortical lateralization is a functional organization observed in most sensory modalities and in the auditory domain, the functional lateralization is devolved to spatial hearing, with each hemisphere primarily involved in processing the localization of sound in contralateral space. The representation of the contralateral auditory field is underpinned by contralateral aural dominance which results from complex neural interactions between inputs from each ear. We showed (Vannson et al 2020) that unilateral hearing loss (UHL) induces deficits in binaural integration (spatial localization and speech understanding in noise) but also reverses contralateral aural dominance in favor of the preserved ipsilateral ear. The extent of this brain reorganization is directly correlated to the extent of spatial behavioral deficit. A second study (Karoui et al 2022) in a group of UHL patients treated with a cochlear implant demonstrated that restoration of auditory inputs to the deaf ear through electrical stimulation restored contralateral hemispheric dominance of both the better and impaired ear. Finally, mirroring what was observed in UHL patients, the extent of restoration of contralateral dominance was directly correlated with the ability to localize sounds after implantation. Lastly in a 3rd group of UHL patients we observed clearly a subgroup of subjects with near normal sound localization performances and a near normal spatial Mismatch Negativity (MMN) a neural marker of spatial abilities. This suggest the existence of behavioral adaptive linked to adaptive brain compensation.
Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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Pascal *	Barone *	CNRS UMR5549
Mathieu	Marx	Service d'Otologie, Otoneurologie et ORL pédiatrique, CHU Toulouse Purpan, France

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Signature Pascal Barone

Brain Plasticity in Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascal Barone

Affiliation CNRS UMR5549

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Signature Pascal Barone

Brain Plasticity in Deafness

Cross-Modal Neuroplasticity in Deafness and Cochlear Implantation

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Anu Sharma

Affiliation The University of Colorado Boulder

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Research Supported by NIH

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Anu *	Sharma *	The University of Colorado Boulder

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Signature Anu Sharma

Brain Plasticity in Deafness

Perinatal Deafness Alters the Structure and Function of Auditory Cortex

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Steve Lomber

Affiliation McGill University Faculty of Medicine

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

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This work was supported by the Canadian Institutes of Health Research.

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Steve *	Lomber *	McGill University Faculty of Medicine
Alex	Meredith	Virginia Commonwealth University

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Signature Stephen Lomber

Brain Plasticity in Deafness

Unilateral Deprivation in Children is Not a “minimal” Hearing loss: Evidence from Measures of Brain Plasticity

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Karen Gordon

Affiliation The Hospital for Sick Children

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Karen *	Gordon *	The Hospital for Sick Children
Blake	Papsin	The Hospital for Sick Children
Sharon	Cushing	The Hospital for Sick Children

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Signature karen gordon

Brain Plasticity in Deafness

Deaf Ear Inhibits Hearing Ear following Single-Sided Congenital Deafness

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Andrej Kral

Affiliation Dept. of Experimental Otology, Medical University Hannover

Participant(s) Pascal Barone (Chair), Anu Sharma (Presenter), Steve Lomber (Presenter), Karen Gordon (Presenter), Andrej Kral (Presenter), Pascale Sandmann (Presenter), Pascal Barone (Presenter)

SUBMISSION DETAILS

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Andrej *	Kral *	Dept. of Experimental Otology, Medical University Hannover

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Signature AK

Brain Plasticity in Deafness

Enhanced Audio-Visual Interactions in Cochlear-Implant Users

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

Submitter Pascale Sandmann

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SUBMISSION DETAILS

Individual Abstract Cochlear implantation has been a well-established procedure to treat patients with severe to profound sensorineural hearing loss. However, a cochlear implant (CI) provides only limited spectro-temporal information, and after implantation, the central nervous system needs to learn to recognise the new, artificial input as meaningful sounds. Interestingly, these cortical changes – also referred to as neuronal plasticity – are not restricted to the auditory system. Rather, CI users show altered cortical processing of both auditory and visual stimuli (Stropahl et al., Hearing research, 2017). In addition, the CI users reveal an increased interaction between the auditory and visual system, which allows improved recognition of speech and environmental sounds when CI users have simultaneous access to auditory and visual information (Radecke et al., NeuroImage Clinical, 2022). This remarkable (behavioural) audio-visual gain in CI users is supported by electroencephalography (EEG) results, which suggest that in the CI users, visual stimuli have a stronger influence on auditory processing when compared to the normal-hearing listeners (Layer et al., NeuroImage Clinical, 2022). Preliminary results suggest that this visual modulation effect is more pronounced in CI users with bilateral hearing loss compared to CI users with unilateral deafness. Nevertheless, both groups of CI users show improved lip-reading ability and increased recruitment of the visual cortex during the processing of auditory and audio-visual speech stimuli when compared to normal-hearing listeners. Overall, these results indicate that CI users develop altered multisensory processing and visual enhancements to compensate for the limited auditory signal provided by the CI.

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In-Person Participation I intend to participate in the MidWinter Meeting in-person for the entirety of the scheduled meeting.

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Brain Plasticity in Deafness

Restoring Cortical Processing for Spatial Hearing following Cochlear Implantation for Asymmetric Hearing Loss

Submission ID 3003152

Submission Type Symposia

Topic Hearing Loss: Consequences and Adaptation

Status Submitted

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SUBMISSION DETAILS

Individual Abstract A cortical lateralization is a functional organization observed in most sensory modalities and in the auditory domain, the functional lateralization is devolved to spatial hearing, with each hemisphere primarily involved in processing the localization of sound in contralateral space. The representation of the contralateral auditory field is underpinned by contralateral aural dominance which results from complex neural interactions between inputs from each ear. We showed (Vannson et al 2020) that unilateral hearing loss (UHL) induces deficits in binaural integration (spatial localization and speech understanding in noise) but also reverses contralateral aural dominance in favor of the preserved ipsilateral ear. The extent of this brain reorganization is directly correlated to the extent of spatial behavioral deficit. A second study (Karoui et al 2022) in a group of UHL patients treated with a cochlear implant demonstrated that restoration of auditory inputs to the deaf ear through electrical stimulation restored contralateral hemispheric dominance of both the better and impaired ear. Finally, mirroring what was observed in UHL patients, the extent of restoration of contralateral dominance was directly correlated with the ability to localize sounds after implantation. Lastly in a 3rd group of UHL patients we observed clearly a subgroup of subjects with near normal sound localization performances and a near normal spatial Mismatch Negativity (MMN) a neural marker of spatial abilities. This suggest the existence of behavioral adaptive linked to adaptive brain compensation.
Altogether, we clearly demonstrated a link between brain reorganization and spatial auditory performance in deafness. Our results are crucial for further progress in the rehabilitation of unilaterally deaf patients and show that the success of rehabilitation depends mainly on brain plasticity mechanisms, and that the restoration of contralateral dominance is essential for an optimal functional recovery.

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