A Machine Learning Study of Auditory Brain Development of Congenitally Deaf Children with Cochlear Implants

Xue Zhao[1], Meiyun Wu[1], Yuhe Liu[2], Yuxuan Zhang[1, *]

[1]State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China

[2]Department of Otolaryngology Head and Neck Surgery, Beijing Friendship Hospital, Capital Medical University, Beijing, China

Email address:

zhangyuxuan@bnu.edu.cn (Yu-Xuan Zhang), liuyuhefeng@163.com (Yuhe Liu), zxue@mail.bnu.edu.cn (Xue Zhao), wumeiyun@mail.bnu.edu.cn (Meiyun Wu)

[*]Corresponding author

Abstract

How the brain development of congenitally deaf children supports their acquisition of auditory and verbal communication skills after cochlear implantation (CI) remains largely in dark. The conventional statistical methods used to analyze neuro-behavioral relationships face significant challenges from the high dimensionality of neuroimaging data. Here, machine learning methods with a nested cross-validation framework were applied to exploring this question. Brain development of CI children (N=50) was longitudinally tracked using functional near-infrared spectroscopy while they were listening to various types of sounds, with at least two valid repeated measurements within about one year of CI activation. Children with low and high behavioral improvement can be distinguished by sound induced activity change between the repeated tests in the bilateral parieto-frontal language network with support vector machine algorithm. The study found a clear advantage of behavioral prediction accuracy for the left over the right hemisphere (72.93% vs. 60.73%) and for speech related over non-speech related stimuli (72.71% vs. 57.05%). The current results suggest that CI mediated auditory experiences allowed the children to develop left-lateralized, speech-specialized processing functions within around one year, and provide the first direct evidence associating such development of lateralized speech processing with the children's behavioral improvement.

Keywords

Machine Learning, Cochlear Implantation, Brain Imaging, Cross Validation