The networks they are a-changin' - Investigating auditory system connectivities during cortical processing of voice, song and music in left-handers and musicians

A. Introduction

1. structures of auditory cortex

- only short talk on non-cortical auditory areas ("ear-structures" and maybe brainstem)
- primary and secondary areas within temporal lobe:
  - Heschel's gyrus: primary auditory cortex and it's tonotopic fields (similarities according to cochlea-functions)
    (Humphries, Liebenthal, & Binder, 2010), (Da Costa et al., 2011)
  - areas around HG: superior temporal gyrus (STG) with localisations of planum polare (PP) and planum temporale (PT): further labelled as secondary or non-primary auditory cortex
  - "higher processing": less tonotopic and more spectrotemporal representations of sound spectrograms with different degrees of spectral and temporal resolution
    (Santoro et al., 2014)

2. processing speech singing and music - differences and similarities

- ongoing discussion: separated neuronal processing and overlaps
  (Tervaniemi, 2006) (Norman-Haignere, Kanwisher, & McDermott, 2015)
  (Rogalsky, Rong, Saberi, & Hickok, 2011)

  a) neuronal processing of speech

  - accurate processing requires fine-graded temporal resolution
  - less important: spectral sampling (only sparse)
  - proposed left-lateralisation of speech-processing
  - pSTG/PT as mentioned neuronal correlates in auditory cortex
  - term voice and not speech, because we are not interested in higher order processing like prosody,...etc.

  b) neuronal processing of music

  - short outlining regarding to music-properties: F0, harmonics and pitch
  - vice versa to speech: finegraded spectral resolution is more important in music than temporal resolution

- proposed right-lateralisation of music-processing
- aSTG/PP as mentioned neuronal correlates in AC

c) singing and it's properties

- properties combine both aspects mentioned in music- and speech processing
  (Schön, Gordon, & Besson, 2005), (Kleber, Birbaumer, Veit, Trevorrow, & Lotze, 2007)

d) choice of stimuli - a gradient of musicality

- 3 stimuli music, song and voice generate a gradient according to spectrotemporal properties
- differences of music and voice and connection via song: sufficient to visualize a more general neuronal system in context of auditory stimuli-processing?

3. influence of handedness and musical training

a) musical training

- induced neuroplasticity according to musical training and it's influence on processing speech and music

(Angulo-Perkins et al., 2014; Elmer, Hänggi, Meyer, & Jäncke, 2013; Meyer, Elmer, & Jäncke, 2012; Schlaug, Jäncke, Huang, & Steinmetz, 1995)

b) handedness

- short introduction according to handedness in general
- left-handers are often mentioned in context of lateralisation, but also often excluded in cognitive neuroscience due to varying neuronal processing strategies compared to right-handers
  (Willems, Der Haegen, Fisher, & Francks, 2014)
- by including left-handers it is aimed to get a more reliable insight in neuronal auditory processing from an other "point of view"
- additional value by including left-handers referred to lateralisation and mentioned occurance in music-, speech-, temporal-, spectral processing

4. aim of the study

- Neuronal connectivity differences within primary and secondary auditory cortex during the processing of voice, song and music shall be investigated; according to this findings the leading question will be further expanded to the influence of handedness and musical training on inter- and intrahemispheric connectivities

- To visualize the information flow of neuronal correlates in an optimal manner of spatial and temporal resolution, combined measurements with fMRI and EEG will be implemented
- ROI's: bilateral HG and STG (PP, PT)

- hypotheses:

  1. How does the application of the mentioned "gradient of musicality", manipulated through presentation of the 3 different auditory stimuli, alter connectivities between areas of auditory cortex?

  2. Do left-handers, respectively musicians show other models of neuronal connectivity than right-handed people without any musical training?

B. Material and Methods

1. participants

- 3 groups recruted: right-handed non-musicians (control group), right-handed musicians, left-handed non-musicians
- definition of "musician" (years of practice, weekly training)
- validation of experimental groups: musical ear test (MET), individual screening formular (reference to appendix), evaluation of handedness (oldfield)
  (Wallentin, Nielsen, Friis-Olivarius, Vuust, & Vuust, 2010)
- amusia-test (MBEA)
  (Peretz, Champod, & Hyde, 2003)

2. stimuli and experimental procedure

- music- and voice-stimuli from Angulo-Perkins et al. (2014; more details: ethic proposal)
- EEG-fMRI combined measurement
- 1 EKG-elektrode for measurement of physiological parameters

3. preprocessing and statistical analysis

- preprocessing as usual for fMRI-data and in addition, if application in python possible, EEG-assisted motion correction (usage of preprocessing pipeline in python)
  (Caballero-Gaudes & Reynolds, 2017; Wong et al., 2016; Zotev, Yuan, Phillips, & Bodurka, 2012)
- GLM, DCM

(Friston, Harrison, & Penny, 2003), (Friston, Holmes, Worsley, Poline, & Frackowiak, 1995)

- adding physiological measurements as nuisance regressors to GLM (if possible)

C. Results

D. Discussion

Appendix

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