Music and language

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Overview

- Objective
  - By the end of this session, you should have a good grasp of key research surrounding music and language in the brain

- To achieve that, during this session we will
  - look at music and language as stimuli
  - take a cognitive neuroscience approach
    - brain areas
    - computations
    - psychological reality
  - discuss what we can conclude from this research

Before we start...

- Any exciting discoveries since our last lecture (before the presentations)?

- Everything ok for assignments?

Music and language

- Do they have anything in common?
- How do they differ?

?

Music and language

- Basic sound properties

  - Sound
  - Timbre
  - Pitch
  - Duration
  - Volume

  - Pitches of a scale in language?
  - Convey same amount of meaning?

Music and language

- Notation

  - Stanzas and lines in in poetry
  - Tonality and rhythmic grouping in music

Music and language

- "Organised" sound

  - Combinatorial

  - Hierarchical structure
  - Structural dependencies (integration efforts)
  - Probabilities
  - Preferences for "predictable" stimuli (i.e. cadence, sentences that end) – simplicity and likelihood

Music and language

- "Organised" sound

  - Language constraints are more rigid than music constraints
  - *Obligatory* dependencies / *Probabilistic* dependencies
  - Music intentionally violates or bends rules for aesthetic effect (language too?); sticking to rules helps message in language
  - Grammatical categories and functions in language only
  - Meaning in music and language?
  - More or less ambiguity

Music and language

- Meaning and emotions

  - Variations in pitch, amplitude, timbre

  - "Meaning" in music as function of relationships between elements vs. immediate semantic content
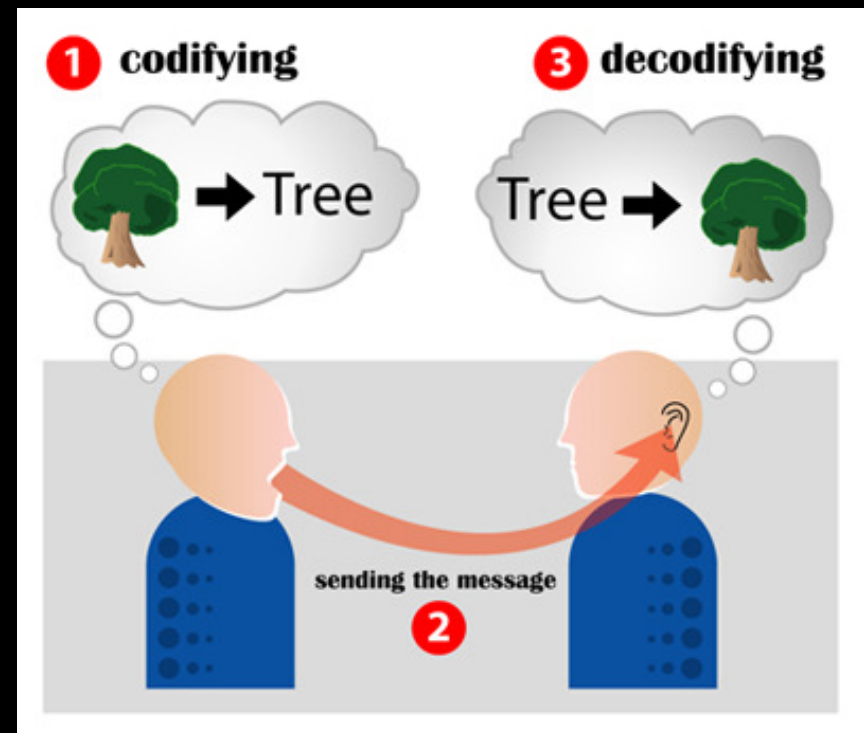
Music and language

- Besson et al (2011) Transfer of training between music and speech: common processing, attention and memory, *Frontiers in Psychology*

  - Rely on the same acoustic parameters: frequency, duration, intensity and timbre
  - Sequential in nature, unfold in time
  - Combinatorial, follow constraints
  - Involve complex processing systems that entertain intimate relationships with attention, memory and motor abilities
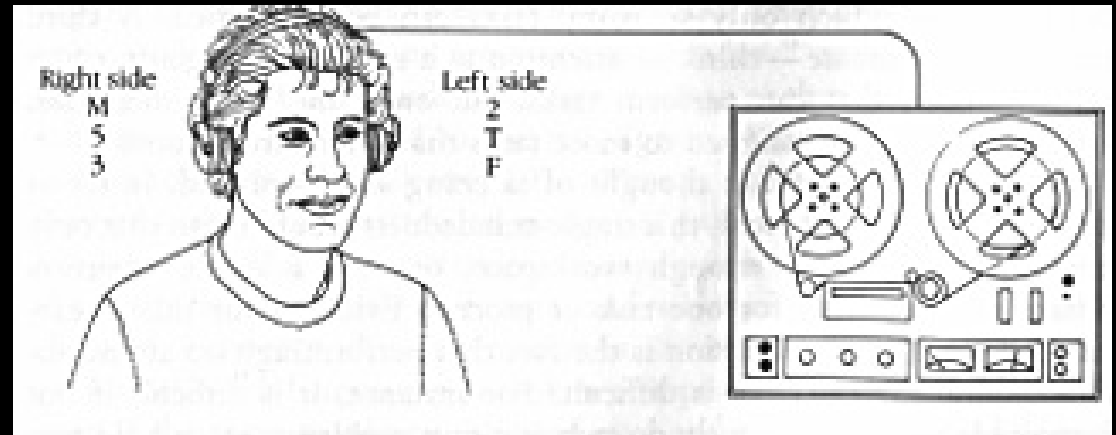
Music and language

- Shared computations?

  - Automatically correct for mistakes (top-down influence)

  - Notion of shared computations across music and language
    - Sound → structured → meaningful units → phrases →...

  - Culture specific aspects vs. Universals → exciting tool for studying the brain more broadly

Music and language

- "The interaction of a stimulus with a perceiving mind"

  - Perceptual input is structured by the mind

  - Perception is facilitated by rules and expectations
   - Statistical preferences
    - Syntactic rules

Early studies

- Investigating music and language "in the brain"
  - Delayed auditory feedback task
  - Dichotic listening task

  - Depending on whether performance is worse in leftor right ear (right or left hemisphere) → "localisation" of music and language
  - Different for different types of stimuli
  - Greater overlap for more complex music stimuli

.... in the brain
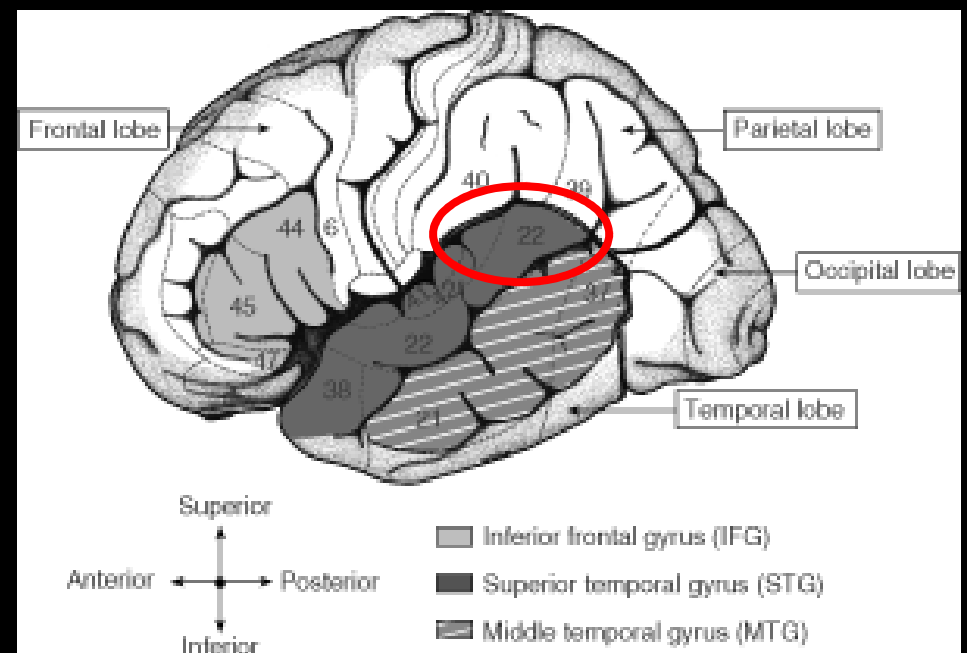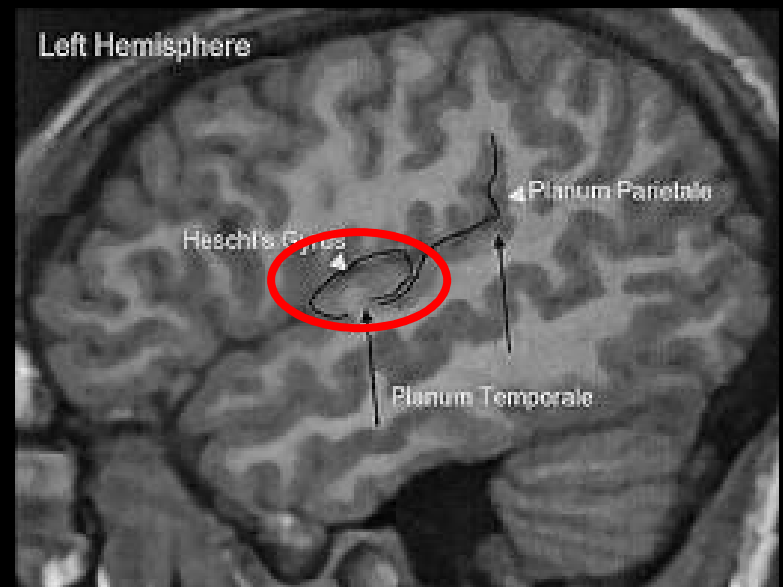
- Initial sound processing
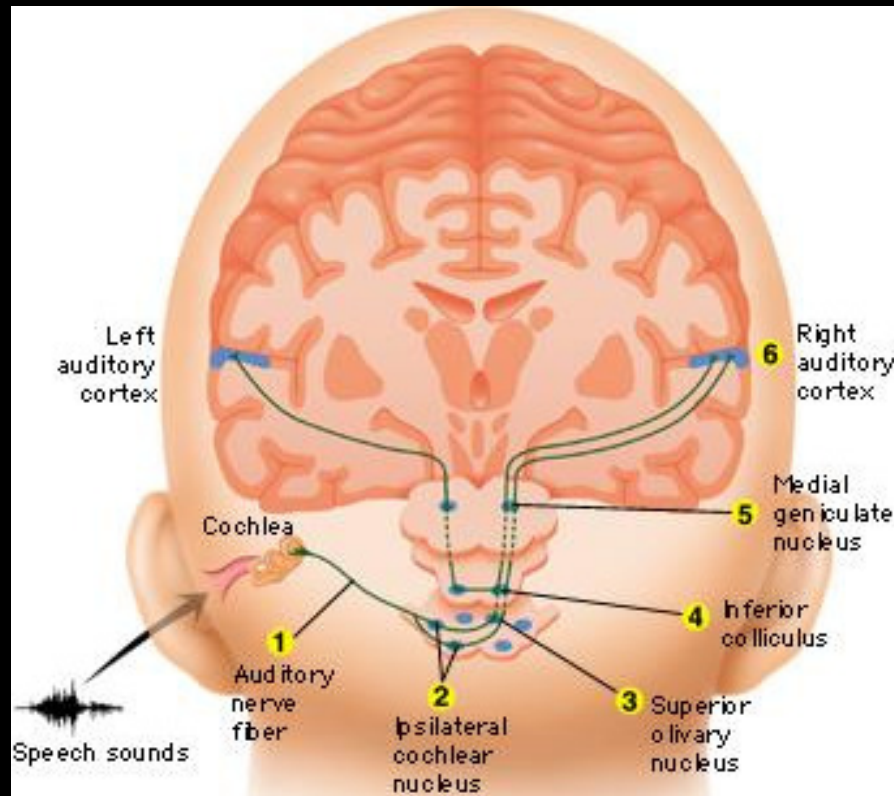
Primary & secondary auditory cortex (BA 41, 42)

Simple stimuli (tones, speech-like sounds)

.... in the brain

- Structuring the sound
  - Heschl's gyrus
  - BA 22 (Planum temporale, Superior Temporal Gyrus)

  - Hippocampus

  - Broca's area

  - Language network

…. in the brain

- What if we process music and language at the same time?

  - Sammler et al. (2010) The relationship of lyrics and tunes in the processing of unfamiliar songs: an fMRI adaptation study, *The Journal of Neuroscience*

  - Same tune / different tune; same lyrics / different lyrics
  - Adapt to just lyrics, adapt to just tune; in some areas lyrics and tune together > lyrics + tune
  → different degrees of integration in processing

.... in the brain

- Brain imaging sufficient to form theories?

- Overlapping areas, but overlapping resources, overlapping computations?

The "incongruity" paradigm

- Kutas (1998, p. 955)

- "If the average ERPs from two experimental conditions differ reliably at any given point in time, it can then be inferred that the associated brain and mental activity also differ at least by that point."

- Turned into "same pattern → same process"
- Controversial, but useful working definition for now

The "incongruity" paradigm

- Music and language both generate expectancies

→ These expectancies can be violated in equivalent ways (Featherstone et al., 2011, Behavior Research Methods)

→ Use these equivalences to study music and language processing in the brain

→ Do we get the same responses...?

ERP methods – quick recap
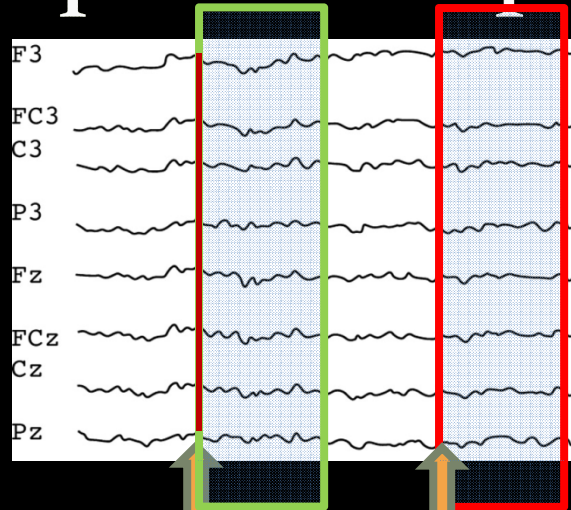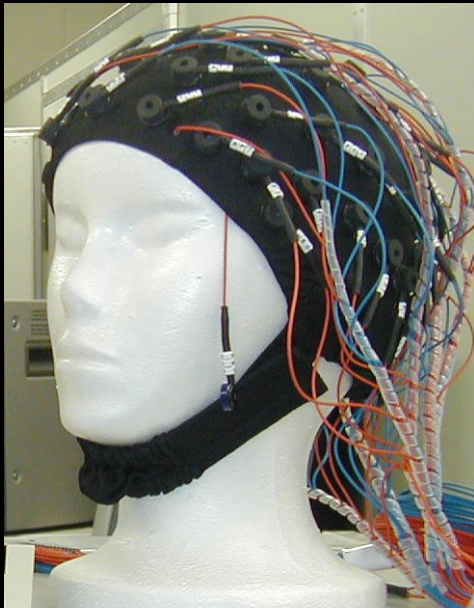
Normal
Incongruous
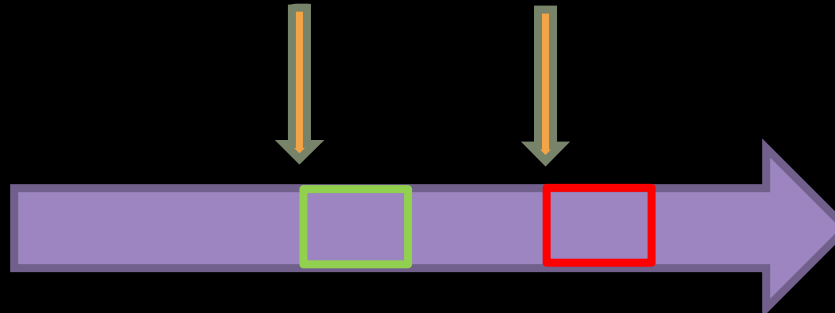
Key studies

- Besson et al (1987)
  - Searching for an N400, building on N400 established in language in the 1980s
    - He buttered his bread with his socks*
    - He buttered his bread with his knife

    - Congruous / incongruous ending of familiar tune
    - Congruous / incongruous ending of scale

  - No N400 found, but Besson's team later found a late positive component

Key studies

- Patel et al. (1998)
  - Sentences with complicated embedded clauses
    - Some of the senators endorsed promoted an old idea of justice.
  - Music with chords borrowed from a different key

  - Late positive component, P600, typical of syntactic incongruities – identical across music and language

  - So harmony = syntax?

Key studies

- Koelsch et al. (2003)
  - Musical chorale-type phrases with incongruous cadences (Neapolitan 6th)

- Effect similar to the N400: the N500 (or N5)
  - – for a review: Koelsch (2011) Towards a neural basis of processing musical semantics, *Physics of Life Reviews*

- Present in non-musicians and in children, but only if had no specific language impairment (see Jentschke, 2005)

- So harmony = semantics? (but what about Besson et al.?)

Overlaps in resources?

- Steinbeis and Koelsch (2008)
  - Present syntactically difficult sentences alongside difficult harmony

  - Find effect of presenting harmonic and semantic incongruities together on amplitude of the N500 / N400

  - So harmony = semantics, and is the route to musical meaning?

Overlaps in resources?

- Slevc, Rosenberg and Patel (2009)
  - Present syntactically difficult sentences alongside difficult harmony
  - Show interaction of harmony on syntactic processes (self-paced reading task)

  - Support for Shared Syntactic Integration Resource Hypothesis (SSIRH)
    - Music and language rely on shared, limited processing resources that activate separable syntactic representations (Patel, 2003)

Other "overlap" studies

- Rhythm processing in BA 47 (Vuust et al., 2006)

- Specific language impairment and music processing (Jentschke, 2005)

- Aphasia and music processing (Platel et al., 2001)

- Music priming semantic meaning (Koelsch, 2004; Daltrozzo et al, 2010) – associations and timbre...?

What is going on?

- How can different studies find different effects?

- Stimuli
- Sample
- Methods
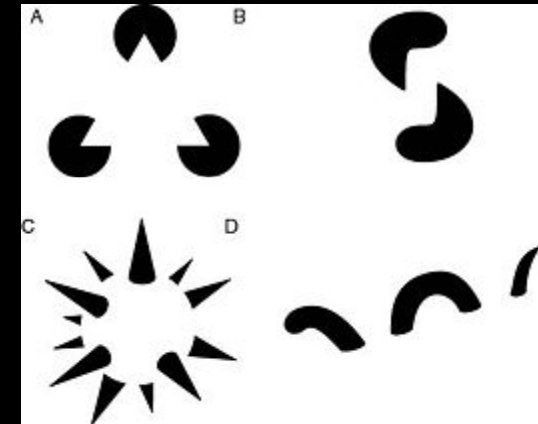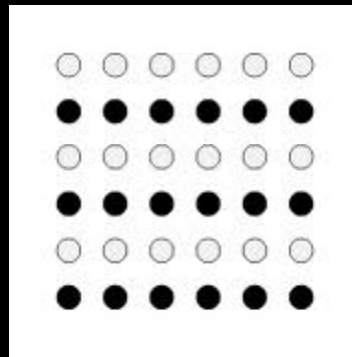- Instructions
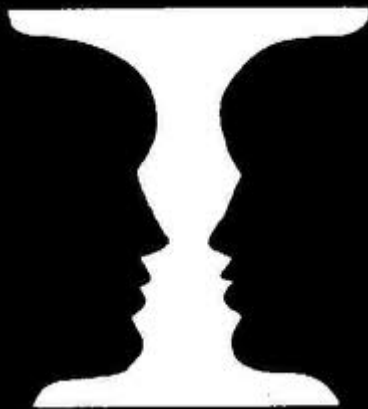- Attention control…

→ Where the method sections come in handy!

Ok, but what does it all mean?

- Music underpins everything?

- Language underpins everything?

- What about maths? (same ERP effects and overlapping areas...)

Ok, but what does it all mean?

- Interaction of stimulus with perceiving mind, in order to make sense of our surroundings

- Marvel at it! (and make the most of it in research...)