What is ‘music’ as a cognitive ability?

- The musical intuitions, conscious and unconscious, of a listener who is experienced in a musical idiom.
- Ability to organize and make coherent the surface patterns of music (pitch, duration, intensity, timbre, etc.)

To what extent are humans’ knowledge about music and knowledge about language similar or different?

To what extent do music and language engage the same processing mechanisms?
How music resembles language

- Uniquely human (as far as we know)
McDermott & Hauser (2004, *Cognition*): **Monkeys miss out on music**

- Unlike humans, cotton-top tamarins do not prefer consonant tones to dashing tones, even though they do prefer soft white noise to loud white noise and feeding chirps to tamarin distress calls.
- Do primates that are more closely related to us (such as chimpanzees) have music? We don’t know yet.
How music resembles language

- Universal
  - All cultures have music.
How music resembles language

- Innate(?)
  - KayShelemay, professor of music at Harvard:
    
    “All humans come into the world with an innate capability for music. At a very early age, this capability is shaped by the music system of the culture in which a child is raised. That culture affects the construction of instruments, the way people sound when they sing, and even the way they hear sound.”
How music resembles language

- Innate(?)
  - Much of the complexity of musical intuition is not learned.
  - Babies respond to music while still in the womb.
  - At 4 months, dissonant tones will cause babies to squirm and turn away.
  - Nazzi, Bertoncini, and Mehler (1998): “That infants have an ability to capture rhythmic information from birth might explain that they will acquire the rhythmic regularities of their native language very early in life.”
How music resembles language

- Hierarchically organized
  - Hierarchy of tension and relaxation.
  - Metrical structure: the intuition that the events of the piece are related to a regular alternation of strong and weak beats at a number of hierarchical levels.
How music resembles language

Grammar of music

- While no two people hear a piece of music the same, there is considerable agreement as to what constitutes “grammatical” music.
- These shared intuitions form a plausible hypothesis for a universal musical “competence”.
How music resembles language

- Productivity
  - If you’re familiar with a musical idiom, you’ll easily recognize a novel instance of that idiom and are able to judge its ‘well-formedness’.
How music resembles language

- Universals
  - It has been argued that all idioms of music share certain properties. For hypotheses about what such universals might be, see Ch 11 in Lerdahl & Ray Jackendoff, 1983, *A Generative Theory of Tonal Music.*
  (downloadable from MIT Cognet: http://cognet.mit.edu/library/books/view?isbn=026262107X)
How music differs from language

Patel:
- No analogue of grammatical categories in music (noun, verb, etc.).
- No analogue of grammatical function in music (subject, object, etc.).
- Syntactic predictions made in language much stricter than in music. For example, a displaced must be followed by a trace.
  
  *The linguist who the neuroscientist met the musician.*
Violating linguistic and musical well-formedness

Figure 1. Syntactic structure associated with the main-verb interpretation of *endorsed* in “Some of the senators endorsed . . .” $S$ = sentence. NP = noun phrase. VP = verb phrase. V = main verb.
Violating linguistic and musical well-formedness


- **Within subjects manipulation of syntactic vs. musical ill-formedness.**

- **Linguistic materials:**
  - **Easy:** Some of the senators had promoted *an* old idea of justice.
  - **Complex:** Some of the senators endorsed promoted *an* old idea of justice.
  - **Ungramm:** Some of the senators endorsed the promoted *an* old idea of justice.

- **Music materials:**
  - **Within key**
  - **Out of key, near-by**
  - **Out of key, distant**
Violating linguistic and musical well-formedness

  - Subjects were musicians.
Result: P600s looks the same both for complexity and ill-formedness (ill-formedness shown below)

Ill-formed - well-formed

Black = linguistic,
Red = music
Eerly Right Anterior Negativity (ERAN)

- Elicited by musical violations only.
ERAN localization
Anyone remember what we know about the localization of the P600?

- Very elusive
  - Patients with left frontal damage show intact P600s
  - Patients with damage in left parietal damage don’t.

(Friederici et al. 1998,1999)
What follows from this?

- That the P600 is not language specific.
- But that’s only interesting if the P600 is part of regular language processing (rather than a generic response to oddness)
  - Recall from our electrophysiology of language lecture that there’s really just been one study showing a P600 effect for grammatical sentences.
  - The interesting question is, to what extent does regular listening to music involve the same neural circuitry as language comprehension?
From the Annual Meeting of the Cognitive neuroscience Meeting (this week):

- Patel, Iversen & Hagoort:
  - Tested a group of Broca’s aphasics for syntactic comprehension and for harmonic priming.
  - BAs were impaired both on the syntactic and language tasks.
After being transduced into neural impulses by the inner ear, information travels through several waystations in the brainstem and midbrain to reach the auditory cortex. The auditory cortex contains distinct subregions that are important for decoding and representing the various aspects of the complex sound.

In turn, information from the auditory cortex interacts with many other brain areas, especially the frontal lobe, for memory formation and interpretation.

The orbitofrontal region is one of many involved in emotional evaluation.

The motor cortex is involved in sensory–motor feedback circuits, and in controlling the movements needed to produce music using an instrument.

REMINDER:
AMUSIA (a subvariety of AUDITORY AGNOSIA)

- Impaired in tasks requiring pattern recognition in music.
- Relative sparing of speech and (other) non-speech perception.
- Damage generally in right temporal areas.
Right brain, left brain...

- Deficits for pitch processing when the right anterolateral part of Heschl’s gyrus is damaged.  
  (Zatorre, 1988; Johnsrude et al. 2000; Tramo et al, 2002)

- Processing of rhythm more bilateral.  
  (Perez & Zatorre, 2005)
Tomorrow’s discussion topic: Is meaning in music anything like linguistic meaning?
Music, language and meaning: brain signatures of semantic processing

Stefan Koelsch, Elisabeth Kasper, Daniela Sammler, Katrin Schulze, Thomas Gunter & Angela D Friederici
ERP Experiment 1

Task:
- Semantic relatedness judgment between prime and target.

Design:
- 2 x 2 crossing prime type (language or music) and relatedness.

Subjects:
- Naïve participants who weren’t familiar with the musical serving as primes.

Dependent measures:
- Behavioral relatedness judgments and the N400
a Language

Related prime: Die Blicke schweifen in die Ferne
(The gaze wandered into the distance)

Unrelated prime: Die Fesseln erlauben wenig Bewegung
(The manacles allow only little movement)

b Music

Related prime: R. Strauss: from Op.54 (Salome)

Unrelated prime: H. Valpola: from the E-minor piece for accordion
- Each target was used four times.
- Each prime was used twice, once as a related prime and once as an unrelated prime.
<table>
<thead>
<tr>
<th>Related prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>narrowness</td>
<td>bird</td>
</tr>
<tr>
<td>basement</td>
<td>staircase</td>
</tr>
<tr>
<td>wideness</td>
<td>mischief</td>
</tr>
<tr>
<td>river</td>
<td>illusion</td>
</tr>
<tr>
<td>staircase</td>
<td>river</td>
</tr>
<tr>
<td>illusion</td>
<td>deviation</td>
</tr>
<tr>
<td>devotion</td>
<td>blossom</td>
</tr>
<tr>
<td>king</td>
<td>needle</td>
</tr>
<tr>
<td>needle</td>
<td>widthness</td>
</tr>
</tbody>
</table>
### Behavioral results (percent correct)

<table>
<thead>
<tr>
<th></th>
<th>Related</th>
<th>Unrelated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Language</td>
<td>93% (±4.1)</td>
<td>91% (±7.3)</td>
</tr>
<tr>
<td>Music</td>
<td>78% (±12.5)</td>
<td>82% (±6.4)</td>
</tr>
</tbody>
</table>
ERP results

a Language

Related prime:
Die Blicke schweifen in die Ferne
(The gaze wandered into the distance)

Unrelated prime:
Die Fesseln erlauben wenig Bewegung
(The manacles allow only little movement)

b Music

Related prime:
R. Strauss: from Op.54 (Salome)

Unrelated prime:
H. Valpola: from the E-minor piece for accordion
ERP difference waves (unrelated - related)
Dipole localization of the N400 effect

Language

\[ x = \pm 43.35, \ y = -34.25, \ z = -3.3 \]
\[ q \ (\text{left} \ / \ \text{right}) = 40.8 \ / \ 30.5 \ \text{nAm} \]

Music

\[ x = \pm 44.75, \ y = -36.95, \ z = -2.65 \]
\[ q \ (\text{left} \ / \ \text{right}) = 57.3 \ / \ 49.1 \ \text{nAm} \]
Behavioral post-test

- 26 different subjects rated in the emotional content of each target word on a 9-point scale, ranging from $-4$ (strong negative content) to $+4$ (strong positive content), with 0 corresponding to emotionally neutral content.
- T-tests were used to determine whether the emotional content of the two target words for a prime differed significantly.
- For 64% of the primes, the two target words (semantically related, unrelated) did not differ in their emotional content, and these items were categorized as emotionally balanced.
Regrouping the data

- Difference waves:

```
Language

Music

---

Emotionally balanced

Emotional content
```
ERP Experiment 2

- **Task:**
  - Attend to the stimuli as you’ll be given a memory test later.

- **Subjects:**
  - New set of naïve subjects.

- **Stimuli:**
  - As in ERP Exp 1.
Results: Identical N400s
Further behavioral test

- Each prime stimulus was presented, followed by a visual presentation of a five-word list.
- This list contained the semantically related and unrelated words used in the ERP experiments, as well as three other words that were randomly chosen from the pool of target items used in the ERP experiments.
- Subjects were instructed to choose the word from the list that had the best semantic fit to the preceding prime stimulus (no subject participated in any of the other experiments).
Results

- After linguistic primes, subjects chose the correct target word in 86% of the trials, well above chance (20%).
- After musical primes, subjects chose the correct target word in 58% of trials, also well above the 20% chance level, but significantly less than in the language domain.