The structure of cognitive and musical abilities

Daniel Müllensiefen, Amit Avron, Naoko Skiada
Simple Questions

- How do musical abilities fit in with other cognitive abilities (types of intelligence)?

- How does musical training affect musical abilities and general intelligence?

⇒ Answers from a model-based approach
Hierarchical models

Spearman‘s model of g

Carroll‘s 3-stratum model
Models of Intelligence

Gardner’s Multiple Intelligences

- Logical
- Linguistic
- Visual
- Naturalistic
- Musical
- Interpersonal
- Intrapersonal
- Kinesthetic
Multiple independent intelligences vs. $g$ (hierarchical intelligence structure)

*How do musical abilities fit in?*
Music As Part of Intelligence Models

- **Visser et al. (2006):**
  - Adult sample
  - 8 types of intelligence (16 tests)
  - Music: Rhythm and Tonal scores from Gordon’s AMMA
  - ⇒ Better support for hierarchical intelligence model
  - ⇒ BUT: Music tests have lowest loadings on g factor

- **Castejon et al. (2010):**
  - Children sample
  - 8 types of intelligence (tests from MI educational platform)
  - Music: Subjective teacher assessment
  - ⇒ Better support for hierarchical intelligence model
  - ⇒ Music scores: moderate loadings on g factors
Does Music Training Increase Intelligence?

- **Correlational studies**
  - + Chen et al. (1998): verbal memory
  - + Schellenberg (2006): IQ
  - + Ruthsatz et al. (2008): g
  - - Schellenberg & Moreno (2010): g
  - + Schellenberg (2011): IQ
  - + Hansen et al. (2012): verbal memory

- **Interventional studies**
  - - Costa-Giomi (1999): numerical, verbal, spatial abilities
  - + Schellenberg (2004): Verbal and visual intelligence
  - + Moreno et al. (2011): Verbal intelligence, but not spatial
  - + Dege & Schwarzer (2011): Phonological awareness
  - - Mehr et al. (2013): Spatial, numerical, visual vocabulary skills
Problems

- **Potential confounders**
  - Socio-economic status (SES, Corrigall et al., 2013)
  - Personality (Corrigall et al., 2013)
  - Self-concept (Dege et al., 2014)
  - Executive function (Dege et al, 2011)
  - ...

- **Measuring musical intelligence**
  - Musical ability tests
  - Teacher assessment
  - Length / intensity of musical training or engagement
The Role of Socio-economic Status

SES → Musical Training → Intelligence

or

SES

Musical Training → Intelligence
Aims of Study

- Do musical abilities fit better with MI or hierarchical model of intelligence?
  - Assess broader range of musical abilities with perceptual tests from Goldsmiths Musical Sophistication Index (Gold-MSI)

- How does musical training impact on musical abilities and other types of intelligence?

- How does SES affect musical training and intelligence?
Study

- **Participants:**
  - N=130, 64% women
  - Age = 26.2 years (SD = 10.2)
  - bias towards higher social classes and education levels

- **Tests:**
  - Wechsler Abbreviated Scale of Intelligence (WASI):
    - Verbal Intelligence: Vocabulary, Similarities
    - Perceptual Intelligence: Block design, Matrix reasoning
  - Gold-MSI perceptual tests:
    - Melodic memory
    - Beat perception
    - Sound similarity
  - Gold-MSI self-report scales, especially Musical Training
  - Socio-economic status (SES): NS-SEC
## Correlations

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.05 uncorrected p-level $\Leftrightarrow r = .18$
Analytical Approach

- **Structural Equation Models**
  - Handles many variables and multi-collinearity
  - Allows for hierarchical models and latent variables
  - Direct and indirect effects (mediation)
  - Enables hypothesis testing of causal effects
  - Simple graphical representation (‘boxes and arrows‘)
1. Multiple independent intelligences

Model fit
CFI: 0.67
RMSEA: 0.17
SRMR: 0.20
BIC: 5121
2. Hierarchical intelligence, music separate

Model fit
CFI: 0.88
RMSEA: 0.11
SRMR: 0.14
BIC: 5097

Musical Intelligence
- Melodic Memory
- Beat Perception
- Sound Similarity

Verbal Intelligence
- Vocabulary
- Similarities

Perceptual Intelligence
- Matrix Reasoning
- Block Design
3. Full hierarchical model

Model fit
CFI: 1
RMSEA: <.001
SRMR: .03
BIC: 5078

Musical Intelligence
- Melodic Memory
- Beat Perception
- Sound Similarity

Verbal Intelligence
- Vocabulary
- Similarities

Perceptual Intelligence
- Matrix Reasoning
- Block Design
## Model comparisons

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Testing the Effects of Musical Training and SES

- Musical Training
- SES
- g
- Musical Intelligence
  - Melodic Memory
  - Beat Perception
  - Sound Similarity
- Verbal Intelligence
  - Vocabulary
  - Similarities
- Perceptual Intelligence
  - Matrix Reasoning
  - Block Design

Model fit:
- CFI: 1
- RMSEA: <.001
- SRMR: .04
- BIC: 6514
Testing the Effects of Musical Training and SES

Musical Training

Musical Intelligence
- Melodic Memory
- Beat Perception
- Sound Similarity

Verbal Intelligence
- Vocabulary
- Similarities

Perceptual Intelligence
- Matrix Reasoning
- Block Design

SES

Model fit
- CFI: .99
- RMSEA: .02
- SRMR: .05
- BIC: 6512
Testing the Effects of Musical Training and SES

Model fit
CFI: 0.98
RMSEA: 0.04
SRMR: 0.07
BIC: 6511
<table>
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<tr>
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<th>$\chi^2$</th>
<th>$p$</th>
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<td><strong>SES affecting only MusTrn</strong></td>
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Best Model

Musical Training

Musical Intelligence

Melodic Memory

Beat Perception

Sound Similarity

Verbal Intelligence

Vocabulary

Similarities

Perceptual Intelligence

Matrix Reasoning

Block Design

SES

Model fit

CFI: .99
RMSEA: .02
SRMR: .05
BIC: 6512

G

1.0

0.92**

1.54*

0.21***

0.08*

0.02
Summary

- Advantages of conceptualizing musical abilities in intelligence framework
- Musical perceptual abilities are best modeled within hierarchical intelligence model
  - But weaker connection than verbal and perceptual intelligence
- Musical training has positive effect on general intelligence
- Socio-economic status affects amount of musical training
Open Question: The arrow of causality
(e.g. Schellenberg, 2011)

Musical Training → Intelligence

Intelligence → Musical Training
The structure of cognitive and musical abilities

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Musical Training

Musical Intelligence
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- Matrix Reasoning
- Block Design

SES

Model fit
- CFI: .97
- RMSEA: .04
- SRMR: .06
- BIC: 6512
Testing the Effects of Musical Training and SES

Musical Training

Musical Intelligence
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SES

Model fit
- CFI: .96
- RMSEA: .05
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