

# Quantifying the musical phenotype: An overview

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# Outline

- What is musicality and why do we need to measure it?
- Overview of the main musical aptitude tests
- Current perspectives and recent developments

## Musicality: some definitions

- Broadly, musicality refers to two concepts:
  1. General ability of humans to make and appreciate music
  2. Individual differences with regard to musical abilities
- Distinction between musical aptitude (*potential* level of musical ability) and musical achievement (*actual* level of musical ability)

# Why do we need to assess musicality?

- Need to develop and validate tools to enable the quantification and analysis of musical aptitude on a large scale
- We cannot rely solely on musical training as a proxy for musical abilities
  - “Musical sleepers”: untrained individuals showing high musical talent or aptitude (Law & Zentner, 2012)

# How can we investigate the biology of musicality?

Various approaches used to investigate the biology of human musicality

Comparative approach



Developmental approach



Neurocognitive approach



Biological/genetic approach



# Large-scale genomics and phenomics of musical aptitude

- Technological developments have made possible large-scale genome-wide association scans (GWAS) studies on larger population samples
- Wide individual variation in music-related skills throughout the general population (Müllensiefen, Gingras, et al., 2014)
- Aim: obtain genomic data *and* an assessment of the musicality **phenotype** that is both reliable and objective, for a large number of people
- Ultimate goal: link specific genomic regions with specific musical phenotypes

# Musical aptitude: different components

- Tonal abilities (pitch perception, harmony perception, singing in a key, hearing separate voices in polyphonic music, etc... )
- Rhythmic abilities (following the beat, tapping etc... )
- Kinesthetic, aesthetic and creative abilities (Shuter-Dyson, 1999)
- Concept of **audiation**: ability to hear music in one's mind (Gordon, 1989)
  - Maybe more important for composers and conductors (Persson, 2009)

# Musical aptitude tests

- Musical aptitude tests usually assess:
  1. Music perception skills
    - Loudness and pitch perception
    - Perception of melodic and/or rhythmic differences
    - In some cases perception of timbre differences, or other parameters
  2. Music production skills
    - Performance abilities (including tapping and singing)
    - Creative abilities (composing, arranging, or improvising)



## Musical aptitude tests: interpreting the scores

- Norms are generally available so that a **standardized score** can be computed: how far is a person's score from the average population score?
- Statistical criteria to assess the quality of a test:
  - **Reliability**: consistency of measurement -> internal consistency and test-retest reliability
  - **Validity**: is the test measuring what it intends to measure? -> convergent and divergent validity
- May include age-specific population norms (same as with intelligence tests)

# The ideal tool for measuring musicality

- The ideal test battery would have these attributes:
  - Captures a broad array of musical skills, involving both perception and production
  - Can be given to individuals with no formal musical training
  - Has a version for preschool children
  - Wide difficulty range (no floor or ceiling effects)
  - Weakly correlated with general intelligence or working memory
  - As culture-independent as possible
  - Includes covariates such as amount of musical training
  - Can be given online
  - Reasonably short duration

# Outline

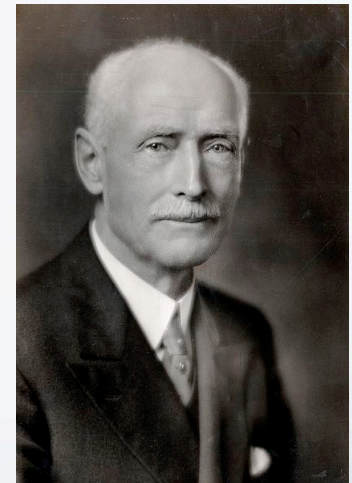
- What is musicality and why do we need to measure it?
- Overview of the main musical aptitude tests
- Current perspectives and recent developments

## Some well-known musical aptitude tests

- Seashore (1919): *Seashore Measures of Musical Talent*
- Wing (1961): *Standardized Tests of Musical intelligence*
- Bentley (1965): *Measures of Musical Abilities*
- Gordon (1965): *Musical Aptitude Profile*
- Gordon (1989): *Advanced Measures of Music Audiation*
- Wallentin et al. (2010): *Musical Ear Test*
- Law & Zentner (2012): *Profile of Music Perception Skills*
- Ullén et al. (2014): *Swedish Musical Discrimination Test*
- Müllensiefen et al. (2014): *Goldsmiths Musical Sophistication Index*

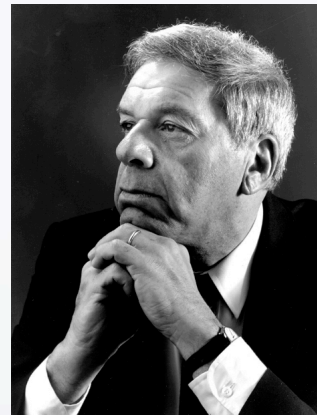
# Seashore Measures of Musical Talent: the first systematic measure of music ability

- First version published in 1919; revised version in 1939
- Main features of Seashore's approach:
  - Musical ability is based on the capacity for **psychoacoustical discrimination**
  - Psychoacoustical skills subdivided into categories
  - These skills are assessed by asking participants to listen and decide whether two simple stimuli are same or different
    - Stimuli: pairs of tones or brief tone sequences
  - Focus on measuring **aptitude**, not achievement



## Other “earlier” tests



- *Wing’s Standardized Tests of Musical Intelligence*: analogous to Seashore’s test, but also aimed to measure aesthetic sensitivity to musical form and performance
- Gordon’s tests focus on audiation and were designed for educational purposes
- Karma Music Test (Karma, 1973; 2007) focuses on the general ability to process auditory patterns
  - The “ability to conceive the structure of acoustic material” underlies culture-specific expressions of musical ability



## “Earlier tests” versus “modern tests”: Different times, different aims

- Few new tests published between 1980 and 2000
- Tests published before 1980 (Seashore, Wing, Gordon, etc...) generally used as a tool to identify children talented enough to receive a formal music education
- Tests published after 2000 (Wallentin et al., Law & Zentner, Müllensiefen et al., etc...) generally used to address research questions relating to the determinants of musical ability
  - Primarily used in cognitive sciences
  - Greater focus on stimulus design and control as well as psychometric qualities (reliability and validity)

# The Musical Ear Test (MET)

- Inspired by Gordon's tests
- Discrimination tasks (same/different)
- Two listening subtests:
  - Short melodies 
  - Rhythmic patterns 
- Test takes ~ 20 min.; no known online implementation
- No ceiling effects, even with professional musicians



# The Swedish Musical Discrimination Test (SMDT)

- Based on discrimination tasks (same/different)
- Three listening subtests:
  - Short melodies
  - Rhythmic patterns
  - Single tones
- Each subtest takes ~4 min.; can be given online
  - Successfully used on large samples of > 6000 individuals
- Adobe Flash Player implementation can be obtained by contacting the first author

# The Goldsmiths Musical Sophistication Index (Gold-MSI)

- Self-report questionnaire
  - Also validated in German (Schaal et al., 2014)
- Two listening subtests:
  - Beat perception: on/off the beat
  - Melodic memory: same/different, based on relative pitch
- Tested on a very large sample (~ 148,000 participants)
- Entire test takes ~ 20 minutes; can be given online



# Gold-MSI self-report questionnaire (sample)

<b>Please circle the most appropriate category:</b>	<b>1 Completely Disagree</b>	<b>2 Strongly Disagree</b>	<b>3 Disagree</b>	<b>4 Neither Agree nor Disagree</b>	<b>5 Agree</b>	<b>6 Strongly Agree</b>	<b>7 Completely Agree</b>
1. I spend a lot of my free time doing music-related activities.	1	2	3	4	5	6	7
2. I sometimes choose music that can trigger shivers down my spine.	1	2	3	4	5	6	7
3. I enjoy writing about music, for example on blogs and forums.	1	2	3	4	5	6	7
4. If somebody starts singing a song I don't know, I can usually join in.	1	2	3	4	5	6	7
5. I am able to judge whether someone is a good singer or not.	1	2	3	4	5	6	7
6. I usually know when I'm hearing a song for the first time.	1	2	3	4	5	6	7
7. I can sing or play music from memory.	1	2	3	4	5	6	7
8. I'm intrigued by musical styles I'm not familiar with and want to find out more.	1	2	3	4	5	6	7
9. Pieces of music rarely evoke emotions for me.	1	2	3	4	5	6	7
10. I am able to hit the right notes when I sing along with a recording.	1	2	3	4	5	6	7

# Gold-MSI:

## Subscales of the self-report questionnaire

- Factor analysis yields a “General sophistication” index and five subscales:
  - Active engagement
  - Perceptual abilities
  - Musical training
  - Singing abilities
  - Emotions

## Gold-MSI: Linking self-report questionnaire and listening tests

- Correlation of .29 between General Sophistication Index and Beat Perception (.27 for Melodic Memory)
- Correlations between Gordon's Advanced Measures of Audiation and self-report between .30 and .51 (n = 44)
  - Upper range of reported correlations between self-report questionnaires and perceptual/cognitive ability tests

# Gold-MSI questionnaire and “Big Five” personality traits

- Openness to experience and Extraversion correlate strongly with general musical sophistication score
- Agreeableness and Emotional Stability also correlated with general musical sophistication, but not as strongly
- High scores on Openness to experience associated with:
  - Cognitive ability (Chamorro-Premuzic et al., 2004)
  - Aesthetic interest (Furnham & Chamorro-Premuzic, 2004)
  - Powerful emotional reactions when listening to music (Vuoskoski & Eerola, 2011)
- Personality predicts musical sophistication scores even after controlling for demographic variables and musicianship, with Openness (specifically Openness to Aesthetics) the best predictor (Greenberg et al., 2015)

## Gold-MSI and socio-demographic variables

- Occupation, occupational status, age, gender, and wealth are the main socio-demographic factors associated with musical sophistication
- Substance use (alcohol, recreational drugs) also predicts musical sophistication

# How to get the Gold-MSI

- All components of the Gold-MSI:
  - Are freely available for research purposes
  - Are fully documented
  - Have data norms derived from an adult population
- Materials for download (documentation and stimuli):  
<http://www.gold.ac.uk/music-mind-brain/gold-msi/>
- Psychopy (Peirce, 2007) implementation of the test available in English and German

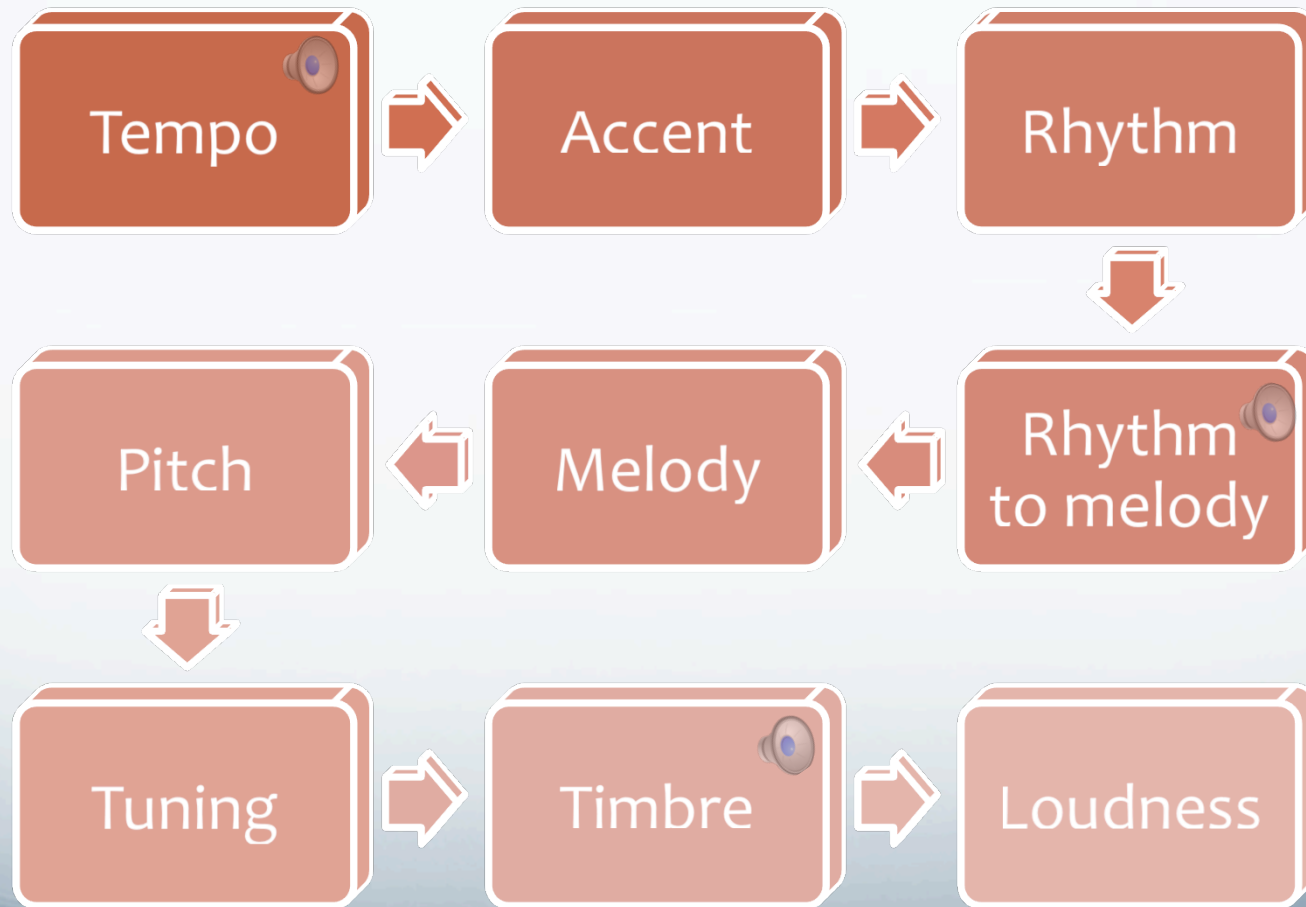


# The Profile of Music Perception Skills (PROMS)

- Discrimination tasks (same/different)
- 9 subtests (see next slide)
- Test aims to be applicable across cultures:
  - Excerpt from South Indian music (Carnatic):
  - Excerpt based on Western tonality:
  - Actual stimulus from the PROMS:
- Entire test takes ~1 hour; can be given online

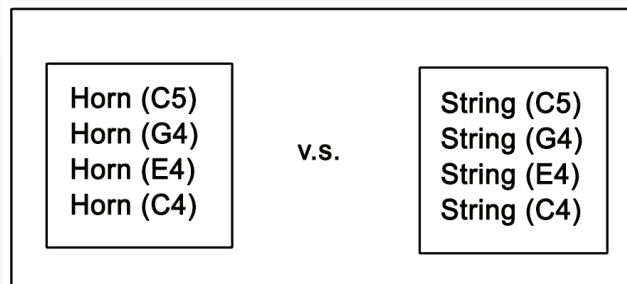


# The Profile of Music Perception Skills (PROMS)

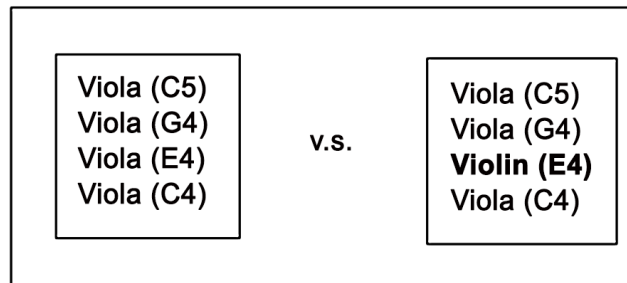


# PROMS: Easy versus difficult tasks

- Example from the timbre subtest:



Example of Easy-Different Trial



Example of Complex-Different Trial

# PROMS: Correlations between musical abilities and other psychological traits

	PROMS (TOTAL SCORE)
<b>Abilities</b>	
Verbal abilities	.35*
Working memory	.30*
<b>IQ</b>	.20
<b>Psychological traits</b>	
Absorption (according to Tellegen)	.40*
Empathy	.30*
Extraversion	.25*

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Values based on work currently in progress (Zentner et al.)

# How to get the PROMS

- How to use the PROMS in your own research:  
[www.uibk.ac.at/psychologie/fachbereiche/pdd/personality\\_assessment/proms/use-the-proms-in-your-own-research/](http://www.uibk.ac.at/psychologie/fachbereiche/pdd/personality_assessment/proms/use-the-proms-in-your-own-research/)
- Shorter versions (Zentner & Strauss, 2017):
  - Short-PROMS (30 min.) has fewer items per subtest
  - Mini-PROMS (~ 15 min.) has only 4 subtests: melody, tuning, tempo, and accent
  - Modular PROMS: Can choose to focus on specific subtests

# The Barcelona Music Reward Questionnaire: Individual differences in ability to enjoy music

- Self-report questionnaire; final version comprises 20 items
- Four factors:
  - Musical seeking
  - Emotion evocation
  - Mood regulation
  - Sensory-motor

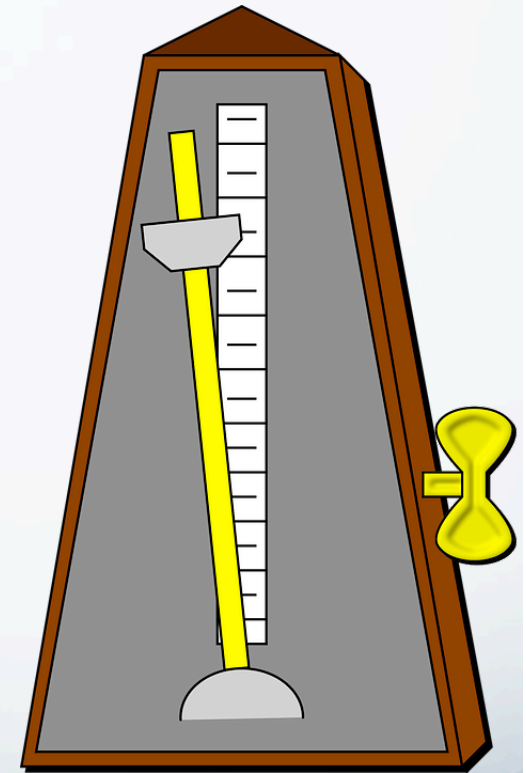


# Tests for special populations

- Distorted Tunes Test (Kalmus & Fry, 1980)  
[www.nidcd.nih.gov/tunetest/take-distorted-tunes-test](http://www.nidcd.nih.gov/tunetest/take-distorted-tunes-test)
  - Used to test for “tone deafness” or dysmelodia
  - Task: Detect “wrong notes” in familiar melodies
  - Used in an early twin study (Drayna et al., 2001): Scores on this test show a heritability of 71 – 80%
- Montreal Battery for the Evaluation of Amusia (Peretz & Coltheart, 2003)
  - Inspired by the DTT but uses novel melodies
  - Six subtests: 3 on melodic organization, 1 on melodic memory, and 2 on temporal organization

# Tapping tests (rhythmic production tasks)

- Beat Alignment Test (Iversen & Patel, 2008)
- BAASTA (Dalla Bella et al., 2016) : includes a perception and a production task
  - Production task based on unpaced and paced finger tapping, synchronization-continuation, and adaptive tapping (with tempo changes)
- Measures of tapping skills require precise reaction times to be recorded
  - May be more difficult to ensure with online tests





# Singing proficiency tests

- Hutchins & Peretz (2012): pitch-matching task
- Berkowska & Dalla Bella (2013): Sung Performance Battery
  - > based on 5 tasks:
    - Single-pitch matching
    - Pitch-interval matching
    - Novel-melody matching
    - Singing familiar melodies from memory
    - Singing familiar melodies at a given (slow) tempo
- May be more difficult to implement online

## Summary: Overview of the characteristics of the main musical aptitude tests

Test	Format	Sample	Sub-tests	Duration	Reliability	
					Int. Consistency <sup>b</sup>	Test-Retest
SMMT (1919)	Offline, LP	C	6	60 min.	.55 to .84 <sup>KR</sup>	NR
STMI (1948)	Offline	C	7	60 min.	.91 <sup>Split Half</sup>	.76 to .88 <sup>r</sup>
MAP (1965)	Offline, CD	C	7	60 min.	.66 to .95 <sup>a</sup>	.77 <sup>r</sup>
KMT (1973, 1975)	Offline, MP3	C & A	1	20 min.	.66 <sup>KR</sup>	.68 <sup>r</sup>
AMMA (1989)	Offline, CD	A	2	20 min.	.83 to .86 <sup>a</sup>	.79 to .84 <sup>r</sup>
DTT (updated) (2001)	Online, CD	A	1	10 min.	NR	.77 <sup>r</sup>
MBEA (2003) <sup>a</sup>	Offline	A	6	90 min.	NR	.75 <sup>r</sup>
MET (2010)	Offline	A	2	20 min.	.94 to .96 <sup>a</sup>	NR
PROMS (2012)	Online	A	9	60 min.	.94 <sup>a</sup> ; .95 <sup>ω</sup>	.88
SMDT (2014)	On/Offline	A	3	10 min.	.79 to .89 <sup>a</sup>	NR
GOLD-MSI (2014)	On/Offline	A	2	20 min.	.65 to .90 <sup>a</sup>	.60 to .70 <sup>r</sup>

Based on Table 1 from Zentner & Gingras (2019)

# Outline

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## Review:

### How close are we to the ideal test battery?

- Captures a broad array of musical skills, involving both perception and production ◆ (*only if we combine several tests*)
- Can be given to individuals with no formal musical training ✓
- Has a version for preschool children ✗
- Wide difficulty range (no floor or ceiling effects) ✓ (*MET, PROMS*)
- Only weakly correlated with general intelligence or working memory ✓ (*PROMS*)
- As culture-independent as possible ◆
- Includes covariates such as amount of musical training ✓ (*Gold-MSI*)
- Can be given online ✓ (*PROMS, SMDT, Gold-MSI*)
- Reasonably short duration ✓ (*SMDT, Gold-MSI, Mini-PROMS*)

## Recent developments: Computerized adaptive testing and item response theory

- Computerized adaptive testing lets the researcher adjust the difficulty level of the stimuli “on the fly” based on the participants’ responses
- Each participant thus completes a task comprised of a different collection of test items
- The statistical basis for this type of testing is known as **item response theory**
  - Responses are modeled for each test item separately and for each individual participant
  - In contrast, the “traditional” method, based on *classical test theory*, analyzes responses on the entire test over the entire sample of participants

# Examples of music perception tests using computerized adaptive testing

- Harrison, Collins, & Müllensiefen (2017): melodic discrimination test
  - Items are generated automatically
- Harrison & Müllensiefen (2018): computerized adaptive beat alignment test
- Larrouy-Maestri et al. (2019): Mistuning perception test

**Thank you for your attention!**

Questions? Comments?

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