Strengths, weaknesses, and alternatives of the musical g-factor as an explanatory model: Evidence from a large longitudinal study

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Main Research Questions

What is the structure of musicality?

How and why are different musical abilities and skills related to each other?

The positive manifold: A universal finding in psychology (e.g. Woodcock, 1990)

Table 1.4: Pearsonian intercorrelation matrix, combined kindergarten to adult sample (decimals omitted). 29 variables from the Woodcock-Johnson psycho-educational battery — revised, $N = 1425$ (correlations corrected for age).

Variable:		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Memory for Names	1	1000																												
Memory for Sentences	2	279	1000																											
Visual Matching	3	213	254	1000																										
Incomplete Words	4	167	255	191	1000																									
Visual Closure	5	148	103	178	176	1000																								
Picture Vocabulary	6	404	403	202	267	229	1000																							
Analysis-Synthesis	7	275	324	280	205	161	323	1000																						
Visual-Auditory Learning	8	542	343	267	192	205	382	376	1000																					
Memory for Words	9	208	559	221	245	046	225	215	246	1000																				
Cross Out	10	170	241	621	168	241	242	291	265	203	1000																			
Sound Blending	11	245	323	245	367	133	323	265	332	335	246	1000																		
Picture Recognition	12	293	216	212	123	234	256	233	299	155	257	212	1000																	
Oral Vocabulary	13	388	534	310	319	234	632	419	405	364	315	389	304	1000																
Concept Formation	14	306	382	306	236	206	325	484	376	227	305	275	269	458	1000															
Memory for Names (Delayed Recall)	15	721	236	155	168	129	383	269	460	173	123	242	236	359	284	1000														
Visual-Auditory Learning (Delayed Recall)	16	345	164	162	120	192	255	269	460	110	168	192	275	271	323	446	1000													
Numbers Reversed	17	259	416	384	227	129	255	368	321	401	309	316	206	396	354	225	182	1000												
Sound Patterns	18	233	257	204	221	109	269	271	259	243	229	294	168	331	299	222	214	282	1000											
Spatial Relations	19	280	266	278	158	265	317	389	369	189	343	225	288	388	404	240	289	311	294	1000										
Listening Comprehension	20	331	469	266	334	204	576	349	344	279	263	351	256	642	375	294	221	308	274	320	1000									
Verbal Analogies	21	379	454	334	228	242	522	455	445	310	344	355	322	639	496	377	330	403	304	465	526	1000								
Calculation	22	256	331	435	142	132	299	423	347	252	358	293	208	471	401	249	242	413	257	376	374	483	1000							
Applied Problems	23	337	416	419	206	175	439	470	388	312	388	360	273	603	489	313	268	438	315	486	524	631	655	1000						
Science	24	380	437	260	285	233	633	368	364	246	280	323	246	658	389	362	270	336	260	385	619	544	440	570	1000					
Social Studies	25	371	477	298	262	200	626	386	374	270	278	323	255	693	411	348	245	332	256	344	638	595	508	617	702	1000				
Humanities	26	390	447	308	281	252	622	343	414	297	284	355	283	665	359	368	283	326	282	340	572	598	427	536	633	672	1000			
Word Attack	27	281	370	356	263	119	316	303	366	322	255	484	202	468	329	269	228	398	316	312	326	415	422	450	346	354	398	1000		
Quantitative Concepts	28	342	427	408	205	162	497	437	416	309	361	320	244	615	413	337	280	433	299	440	513	624	656	728	602	637	576	471	1000	
Writing Fluency	29	225	350	494	193	123	260	309	347	266	410	358	196	398	335	197	194	365	229	276	285	394	420	426	293	336	409	488	434	1000

… and in music / auditory psychology

Stankov & Horn (1980)

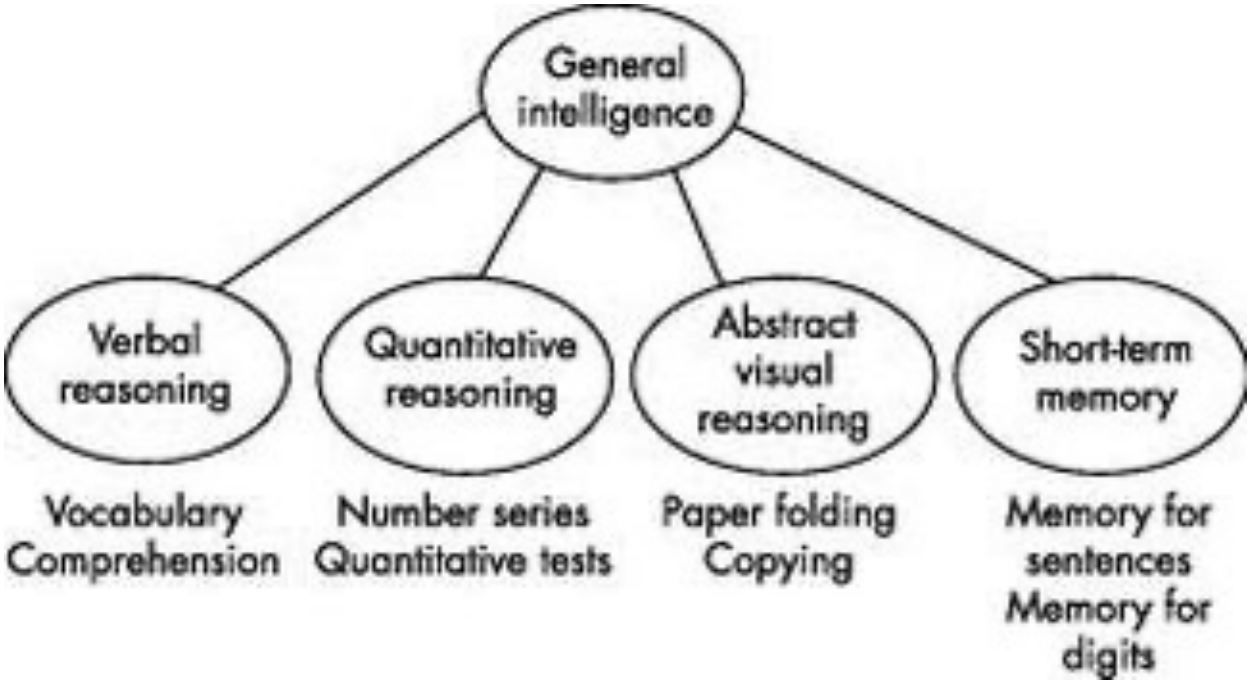
	STAN21 3-26-10													
Var #	Variable Name	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Pitch Change in Chords	1.00												
2	Seashore's Tonal Memory	0.65	1.00											
3	Chord Decomposition	0.55	0.61	1.00										
4	Notes Per Chord	0.32	0.34	0.40	1.00									
5	Letter Reordering	0.32	0.50	0.28	0.11	1.00								
6	Tonal Reordering	0.24	0.26	0.17	0.12	0.37	1.00							
7	RST Test	0.08	0.11	0.12	-0.04	0.44	0.23	1.00						
8	Do-Mi-Sol Test	0.36	0.31	0.36	0.12	0.32	0.41	0.27	1.00					
9	Tempo A	0.10	0.41	0.21	0.18	0.27	0.10	0.25	0.07	1.00				
10	Tempo B	0.12	0.32	0.09	-0.01	0.39	0.16	0.31	0.27	0.67	1.00			
11	Spoken Synonyms Vocabulary	0.16	0.23	0.30	0.20	0.31	0.19	0.06	0.00	0.10	0.02	1.00		
12	Rapid Spelling	0.14	0.14	0.06	0.18	0.16	0.07	0.03	-0.01	0.13	0.02	0.55	1.00	
13	Number Span Forward	0.16	0.19	0.07	0.01	0.36	0.11	0.17	-0.06	0.14	0.07	0.27	0.40	1.00

Other examples: Kidd et al. (2007), Law & Zentner (2012), Barros et al., (2017)

Why are tests of (listening) ability always positively correlated?

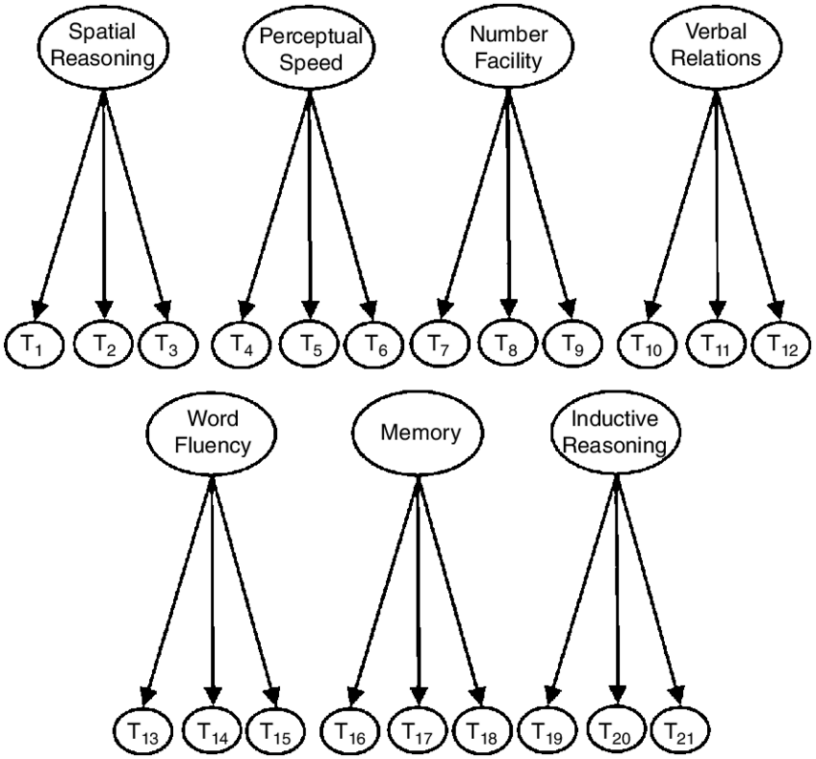
Answers from intelligence research

General (g) factor of intelligence (Spearman, 1904; 1927)



Multiple factors of loosely related abilities

(Thurstone, 1938)



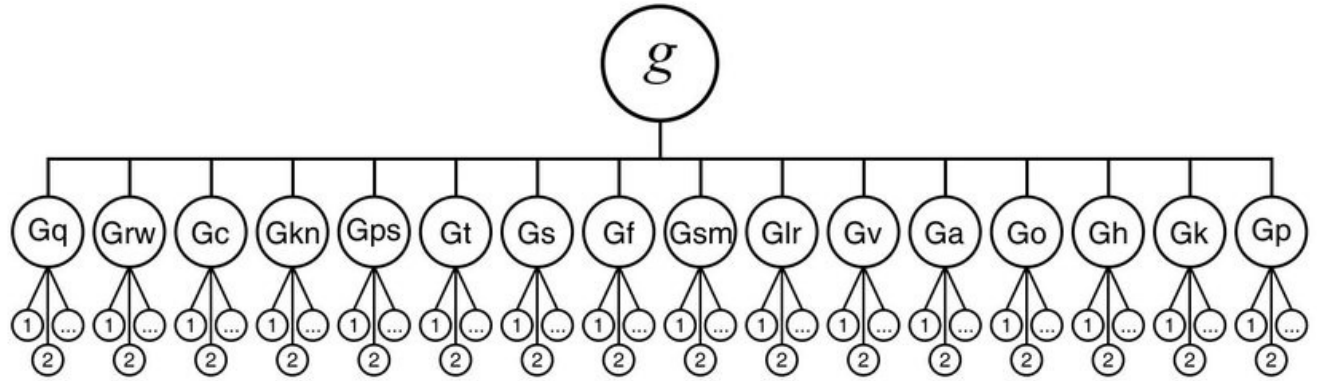
Hierarchical model of cognitive abilities

(Carroll, 1993; CHC theory, McGrew, 2009; Schneider & McGrew, 2018)

III General

II Broad

I Narrow



Third-order factor:

g - General Intelligence

Second-order factors:

Gq - Quantitative Knowledge
Grw - Reading and Writing
Gc - Comprehension Knowledge
Gkn - Domain-Specific Knowledge

Gps - Psychomotor Speed
Gt - Reaction and Decision Speed
Gs - Processing Speed
Gf - Fluid Reasoning

Gsm - Short-Term Memory
Glr - Long Term Storage and Retrieval
Gv - Visual Processing
Ga - Auditory Processing

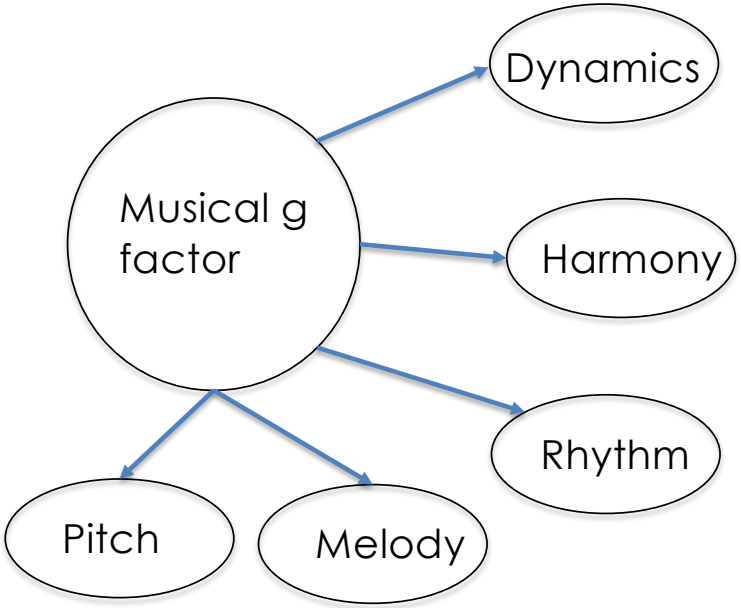
Go - Olfactory Abilities
Gh - Tactile Abilities
Gk - Kinesthetic Abilities
Gp - Psychomotor Abilities

Multiple (unrelated) intelligences (Gardner, 2006)

Doesn't explain positive manifold

Most appropriate model for musical ability?

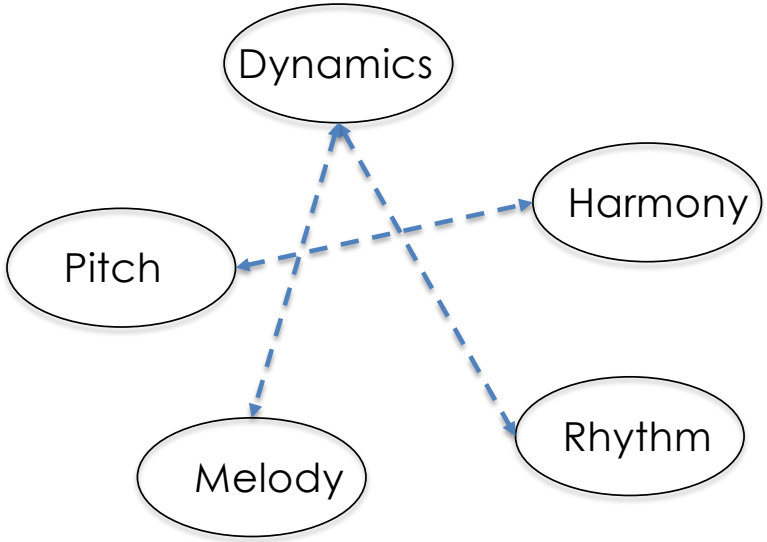
Musical g factor



Wing, 1938

vs.

Set of loosely related talents



Seashore, 1939

vs. ?

Other models

The musical g factor concept

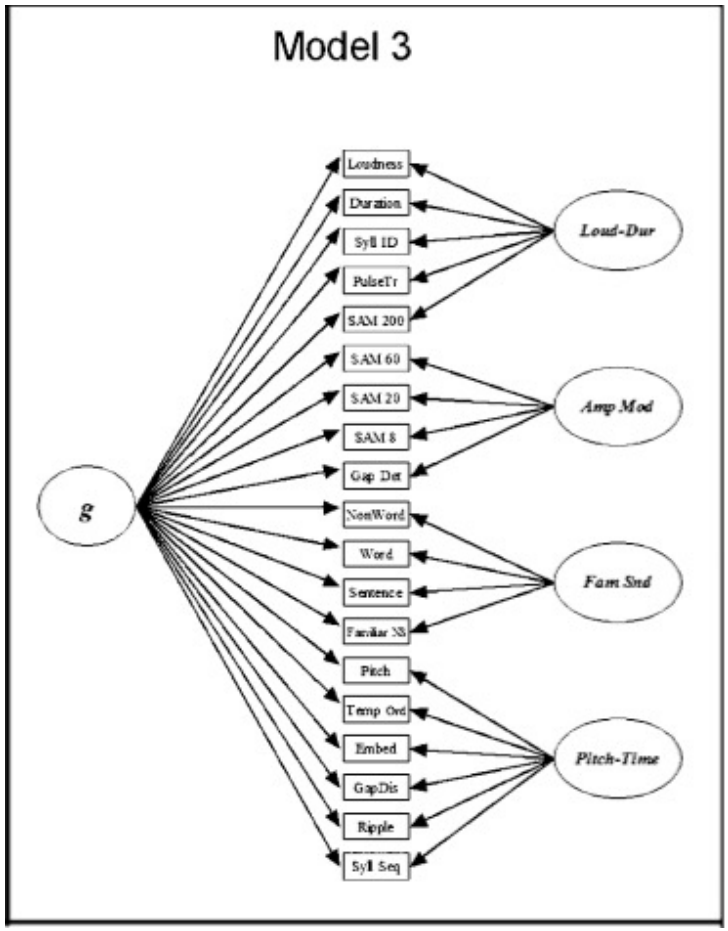
Strengths

- Simple and parsimonious explanation of the positive manifold
- Compatible with current intelligence models (CHC theory)
- Investigating relationship of musicality to other domains (speech, genetics) is straightforward

Weaknesses

- Needs assumptions of latent factor model (Borsboom et al., 2003)
- Relies on specific analysis technique (factor analysis) and type of tests
- Data-driven and sometimes producing results difficult to interpret
- Not differentiating between types of music, developmental trajectories or levels of expertise

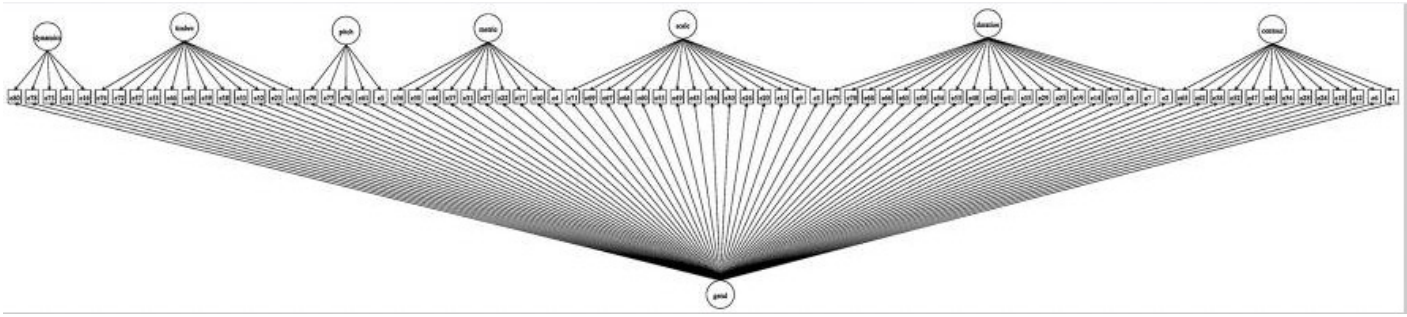
Empirical support from previous studies



Kidd et al., (2007)

- Test of Basic Auditory Capabilities (TBAC): 19 auditory / psychoacoustic tests
- 340 adults
- Best support for hierarchical bi-factor model including auditory g
- Group factors:
  - Loudness & Duration
  - Amplitude Modulation
  - Familiar Sounds
  - Pitch & Time
- Data openly accessible

Empirical support from previous studies



Barros et al., (2017)

- 7 ad-hoc same-different musical discrimination tests; 80 items total
- 1006 young children (6-13 years)
- Best support for hierarchical bi-factor model including musical g (“m”)
- No good support for existence of group factors => suggestion to only only report overall score of 80 items.

Is there support for the g factor model from a battery of higher-level music perception tests that were designed independently of each other?

Method

Assumption:

Musicality / musical abilities can be measured by performance tests of music perception skills

Important:

Tests are designed to measure only one specific skill, independently from other tests and without any reference to a common factor

Example: BAT

Beat Alignment Test

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Question 1 out of 15

0:12 / 0:12

One of these clips has beeps on the beat, the other off the beat.

Which clip had beeps **on** the beat? If you don't know, give your best guess!

First Second

Example: MDI

Melodic Discrimination Test

Example: MPT

Mistuning Perception Test

Goldsmiths
UNIVERSITY OF LONDON

Question 1 out of 30

0:04 / 0:14

Which version was **out of tune**?

If you don't know, give your best guess!

Listening tests in this study

- MDI: Melody discrimination (Harrison, Collins, & Müllensiefen, 2017)
- BAT: Beat Perception (Harrison & Müllensiefen, 2018)
- MPT: Mistuning perception (Larrouy-Maestri et al., 2019)
- EDT: Emotion Discrimination (MacGregor, Ruth & Müllensiefen, 2023)
- PIAT: Pitch imagery (Gelding et al., 2020)
- BDT: Beat Drop Test (Cinelyte et al., 2022)
- MSA: Musical Scene Analysis (Hake et al., 2023)
- HPT: Harmony perception (Eitel et al., 2024)
- RAT: Rhythm Perception (MacGregor et al., in prep.)

Data collection: The *LongGold study*

- Longitudinal study on development of musical abilities during adolescence
- Investigates relationships with general cognition, academic achievement, psychosocial skills

Data from 13 schools in UK and Germany

The cross-sectional sample

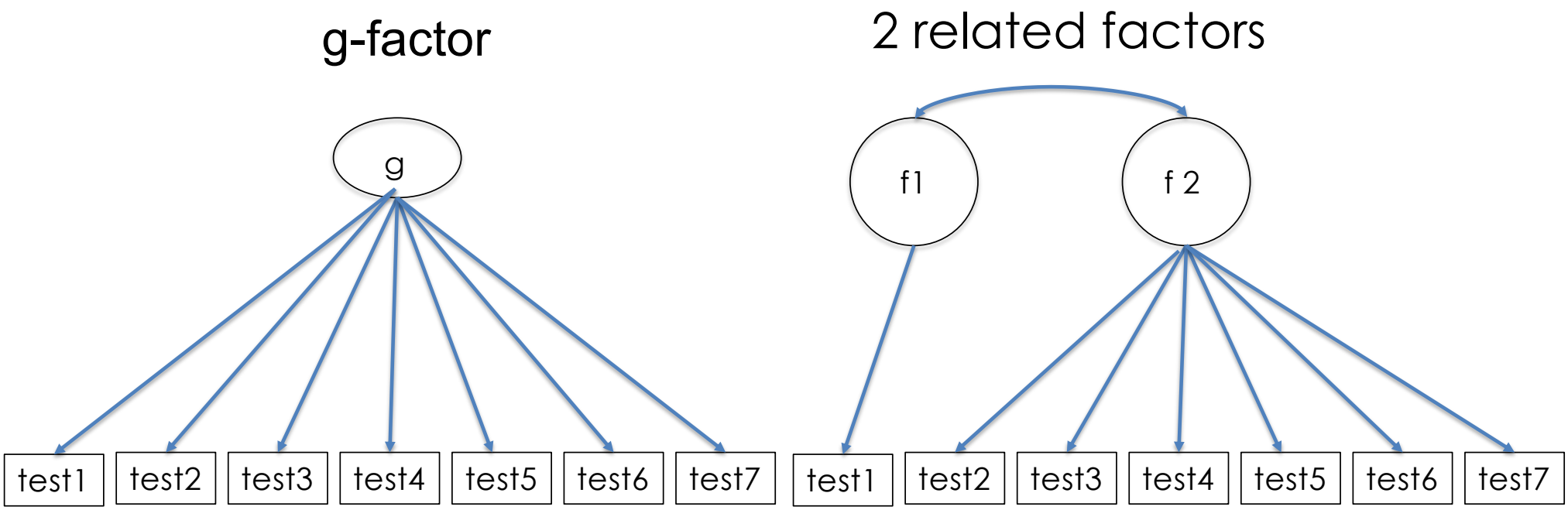
- 3814 students from UK and Germany
- Use each participant only once, i.e. in year where participant took max no. of tests (ø no. tests: 4.75)
- Age: ø 13.6 years (SD = 1.7)
- 59 % ♀ & 37 % ♂ 4% ⚧

Research questions

- *How is performance across various musical ability tests related (if at all)?*

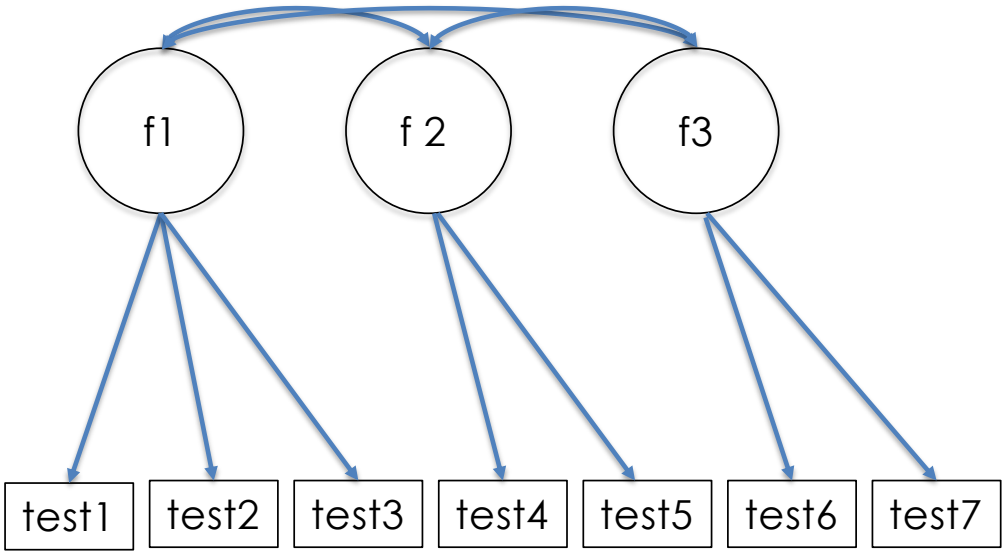
- *Is there one or more latent variable(s) to explain relationships?*

Models considered

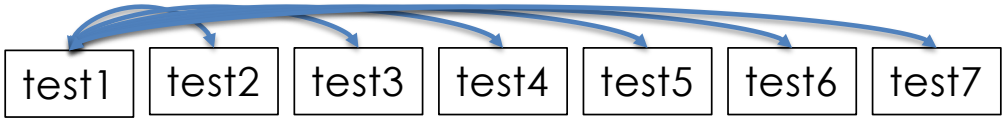


Possible models

3 related factors



No common factor, just individual correlations



Results: Correlations of Test Scores

	BAT	*EDT*	*HPT*	*MDI*	*MPT*	*PIAT*	*RAT*	*MSA*	*BDT*
BAT	0.565	0.340	0.570	0.605	0.589	0.544	0.620	0.440	0.528
EDT	0.219	0.735	0.312	0.309	0.336	0.511	0.329	0.330	0.222
HPT	0.378	0.236	0.779	0.691	0.647	NA	0.600	0.549	0.371
MDI	0.349	0.203	0.468	0.589	0.656	0.651	0.677	0.567	0.413
MPT	0.346	0.225	0.446	0.393	0.61	0.617	0.502	0.312	0.284
PIAT	0.298	0.319	NA	0.364	0.351	0.531	0.585	NA	NA
RAT	0.409	0.247	0.464	0.456	0.344	0.374	0.769	0.467	0.430
MSA	0.302	0.258	0.442	0.397	0.222	NA	0.374	0.833	0.286
BDT	0.301	0.144	0.248	0.240	0.168	NA	0.286	0.198	0.574

Computed correlation used pearson-method with pairwise-deletion.

Results

Analysis strategy:

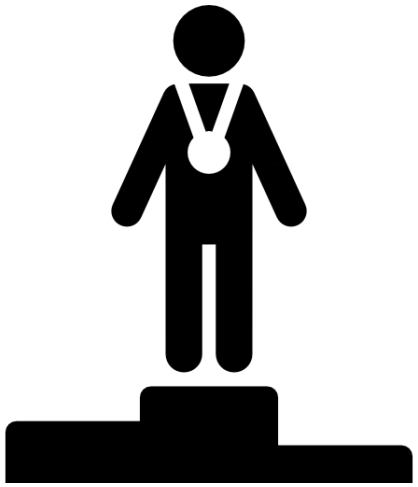
1. Run exploratory factor analysis for 2- and 3-factor model
2. Compare 1-, 2-, 3-, and no-factor model by confirmatory factor analysis

Results: Confirmatory Factor Analysis

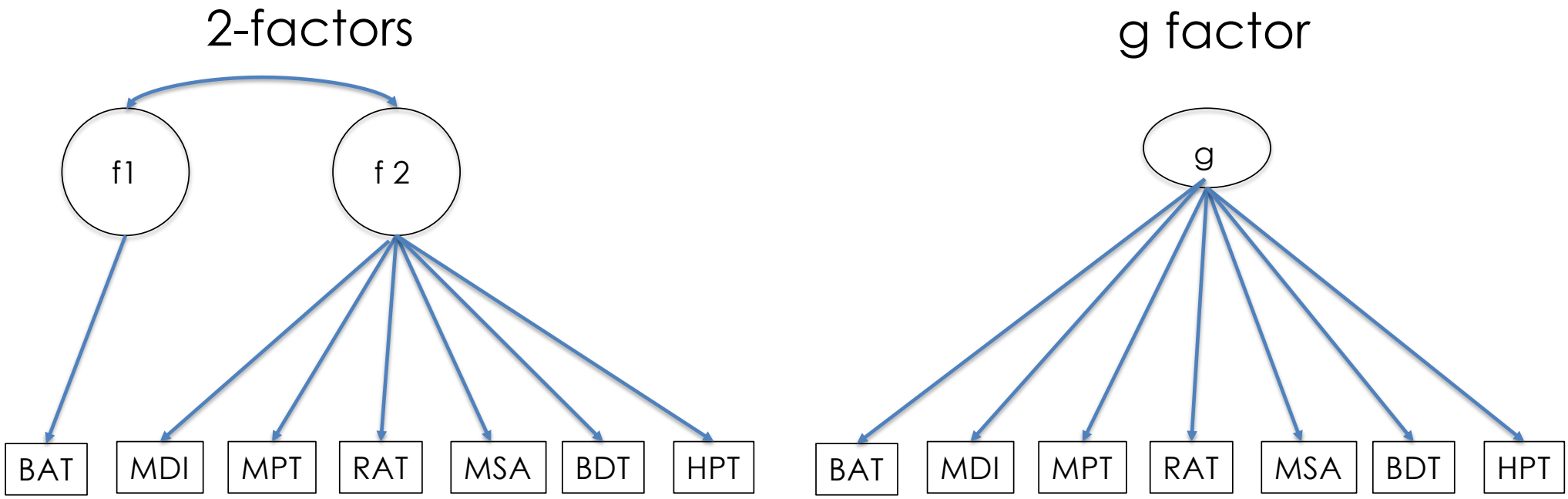
Model	DF	BIC
No common factor	0	47250
3-factor model	13	47189
2-factor model	14	47183
g-factor model	14	47183

No clear winner?

2-factor model and g-factor model have the same fit to the data



Winnings models



g factor model summary

Fit measures

RMSEA = .025 (robust RMSEA = .049)

SRMR = .035

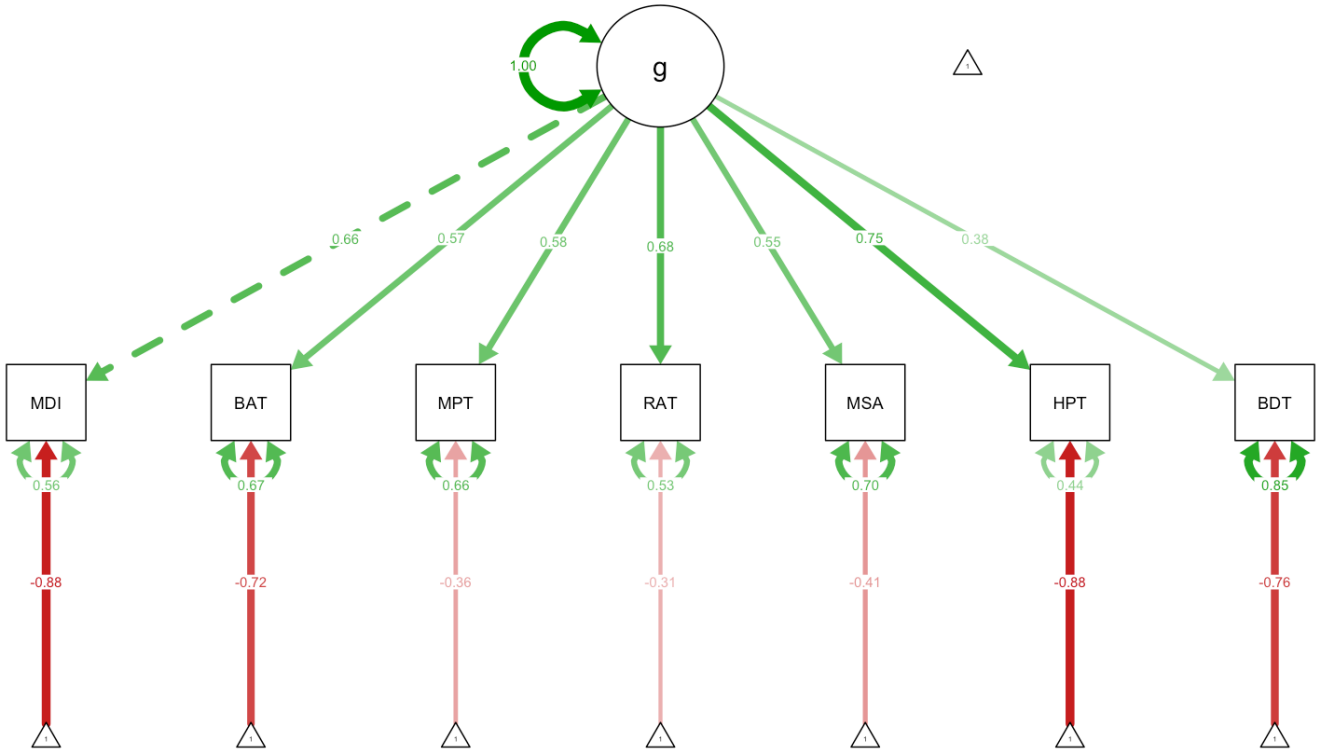
CFI = .987 (robust CFI = .980)

TLI = .981 (robust TLI = .970)

Latent Variables:

	Estimate	Std.Err	z-value	P(>|z|)	Std.lv	Std.all
g =~						
MDI.score	1.000				0.778	0.663
BAT.score	0.930	0.037	25.348	0.000	0.723	0.572
MPT.score	0.869	0.034	25.923	0.000	0.676	0.581
RAT.score	0.872	0.035	25.099	0.000	0.678	0.683
MSA.score	0.774	0.054	14.447	0.000	0.602	0.551
HPT.score	0.969	0.045	21.672	0.000	0.754	0.748
BDT.score	0.580	0.087	6.632	0.000	0.451	0.383

Let’s accept the g-factor model for now



Discussion and next steps

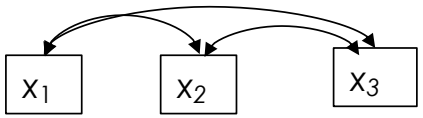
- Fix data issues with EDT and PIAT
- Test invariance of g factor model across gender, across time (longitudinally), across age groups longitudinally
- Compare to self-reported ability data (MusicGens17)
- Where does g factor come from (genes, training, GxE interaction)?

Compare to alternative classes of models

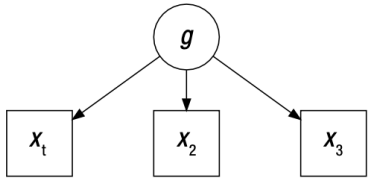
Loose collection of modular musical skills (Gardner, Seashore)

vs

Different facets of underlying general construct musicality (Spearman, Wing, Thurstone)



a

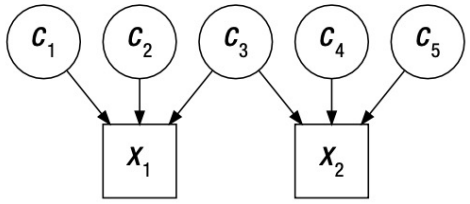


or

Sampling from many basic perceptual & cognitive skills (Thompson, 1926; Kovacs & Conway, 2016)

Gene-environment interaction models (Dickens & Flynn, 2001) or network model (van der Maas et al., 2019)

b



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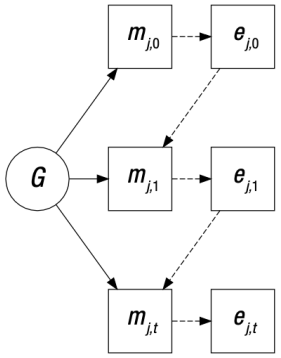

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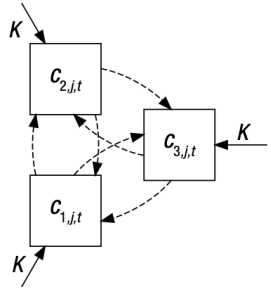

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