LONGGOLD

Goldsmiths
UNIVERSITY OF LONDON

HANOVER MUSIC LAB

THE DEVELOPMENT OF COGNITIVE AND MUSICAL ABILITIES: PRELIMINARY RESULTS OF THE LONGGOLD STUDY

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THE GENERAL QUESTION

What role do musical abilities and activities play in human development across the teenage years?

SPECIFIC RESEARCH QUESTIONS

- How do musical abilities still grow beyond 10?
- To what degree is development due to maturation vs. musical training and activity?
- How do musical abilities interact with cognitive skills?

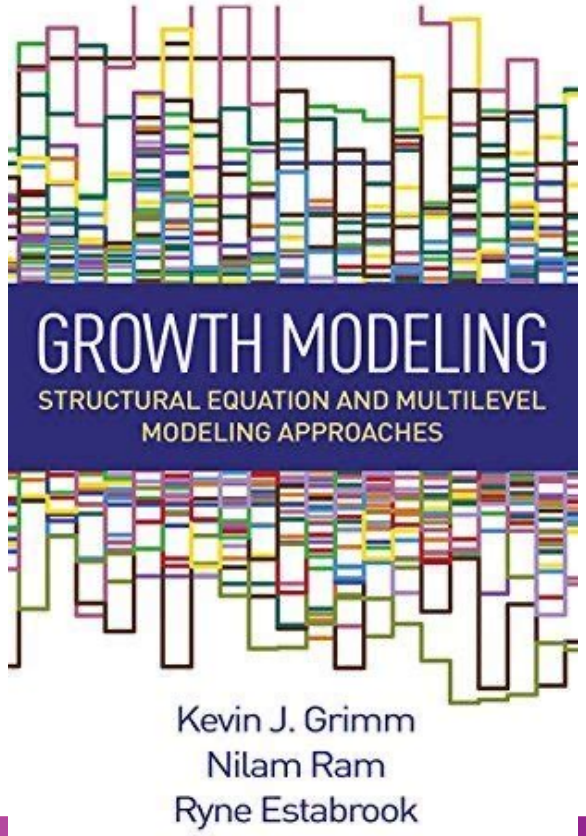
ANALYSING CHANGE IN LONGITUDINAL DATA

(Baltes & Nessleroade, 1979; McArdle & Nesslroade, 2014)

1. Developmental trajectories (intraindividual change): *How do kids develop over time?*
2. Differences in developmental trajectories (individual differences in intraindividual change): *How much do kids differ in their development?*
3. Co-development of trajectories in different areas (interrelations in behaviorial change): *How does development in different areas co-evolve?*
4. Variables explaining developmental trajectories (causes of intraindividual change): *What are the factors that drive development?*
5. Variables explaining differences in developmental trajectories (causes of interindividual differences in intraindividual change): *Why do some kids develop differently from others?*

TWO FRAMEWORKS FOR ANALYSING LONGITUDINAL DATA

1. *Mixed effect models (= multilevel models): Growth curves*
   - *Pro: Easier to specify, quicker to compute, Bayesian extension via R package brms*
   - *Con: Restricted in specification (e.g. correlation between predictors), can't include measurement error directly, can't investigate causality easily*
2. *Structural equation models: Latent growth curves, (random-intercept) cross-lagged panel models, dual-change score models*
   - *Pro: Very flexible specification, can investigate causality (via model comparison in cross-lagged panel or dual-change score models), can specify measurement error as part of model*
   - *Con: Difficult to specify, complex to compute, difficult to disseminate and explain*



RESULTS

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ORIGINAL ARTICLE

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES

Musical development during adolescence: Perceptual skills, cognitive resources, and musical training

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Abstract

Longitudinal studies on musical development can provide very valuable insights and potentially evidence for causal mechanisms driving the development of musical skills and cognitive resources, such as working memory and intelligence. Nonetheless, quantitative longitudinal studies on musical and cognitive development are very rare in the published literature. Hence, the aim of this paper is to document available longitudinal evidence on musical development from three different sources. In part I, data from a systematic literature review are presented in a graphical format, making developmental trends from five previous longitudinal studies comparable. Part II presents a model of musical development derived from music-related variables that are part of the British Millennium Cohort Study. In part III, data from the ongoing LongGold project are analyzed answering five questions on the change of musical skills and cognitive resources across adolescence and on the role that musical training and activities might play in these developmental processes. Results provide evidence for substantial near transfer effects (from musical training to musical skills) and weaker evidence for far-transfer to cognitive variables. But results also show evidence of cognitive profiles of high intelligence and working memory capacity that are conducive to strong subsequent growth rates of musical development.

KEYWORDS
adolescence, intelligence, longitudinal study, music perception, musical development, working memory

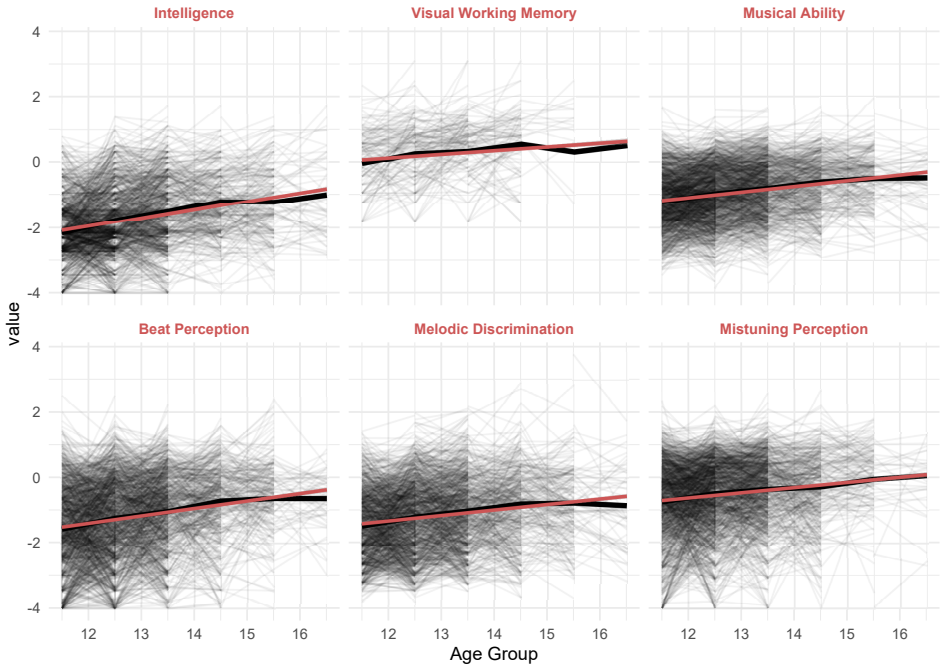
INTRODUCTION

Adolescence[a] is a decisive period in human development where neuro-plasticity is high, many cognitive skills are acquired,[1] important socioemotional changes take place, and self-identities[2] are formed. For many individuals, adolescence is the period that includes a conscious and self-directed choice to engage with music intensively and devote personal resources to instrumental practice and music playing (or not).[3] The musical choices individuals make during adolescence often set the path for the type and intensity of engagement with music across a lifetime.[4] At the same time, adolescence can be an important period of development for cognitive resources, such as working memory or general intelligence, and opportunities for cognitive growth through external stimulation (e.g., musical or other forms of specialized training), which are considered highly important.[5]

[a] For the purpose of this paper, we generally follow the WHO's definition of adolescence as "the phase of life between childhood and adulthood, from ages 10 to 19." See: WHO, 2022; https://www.who.int/health-topics/adolescent-health#tab=tab_1. However, in parts I and II, we also consider data from the childhood years as these are closely related to the adolescent data presented.

1. INTRA-INDIVIDUAL CHANGE

All cognitive and musical capacities grow with age

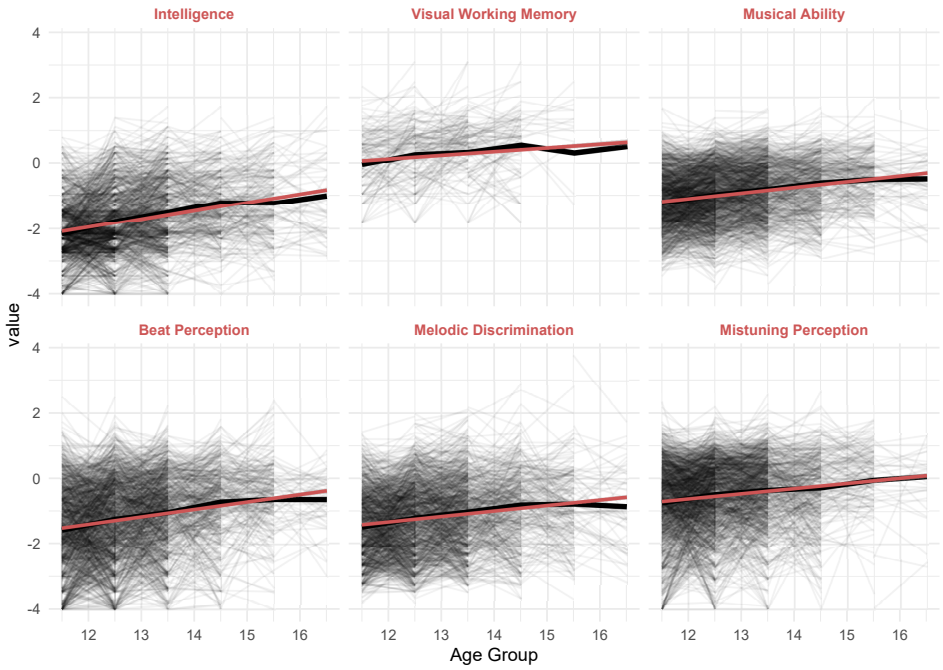


Variable	beta	95% CI	p
Intelligence	0.26	[0.24, 0.27]	< .001
Visual Working Memory	0.11	[0.09, 0.14]	< .001
Musical Ability	0.17	[0.16, 0.19]	< .001
Beat Perception	0.23	[0.21, 0.25]	< .001
Melodic Discrimination	0.17	[0.15, 0.19]	< .001
Mistuning Perception	0.16	[0.14, 0.18]	< .001
Musical Training	0.02	[-0.00, 0.04]	.118

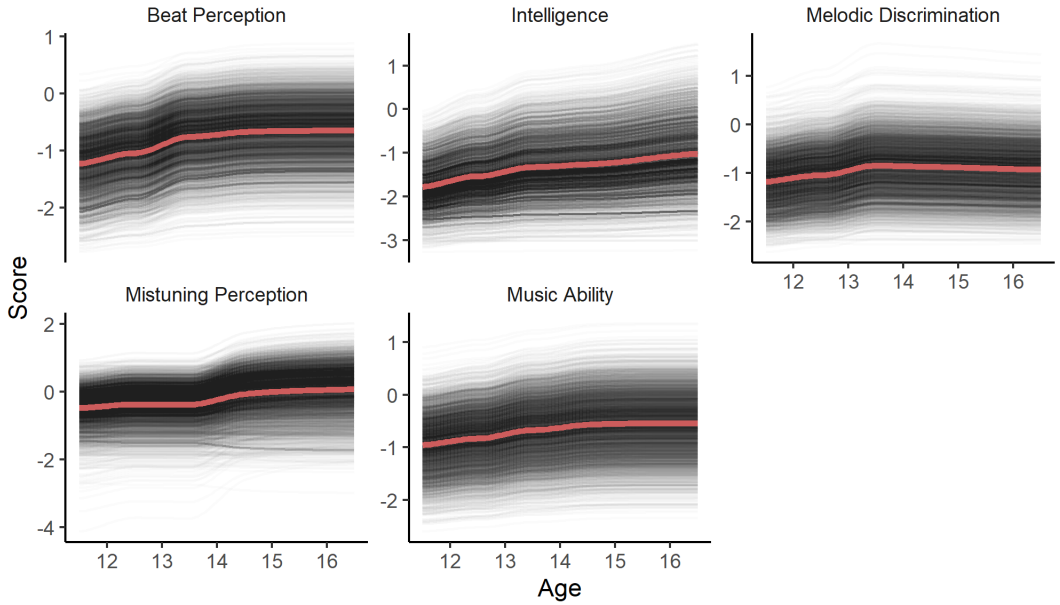
1. INTRA-INDIVIDUAL CHANGE

All cognitive and musical capacities grow with age

Linear growth assumed (mixed effect model)

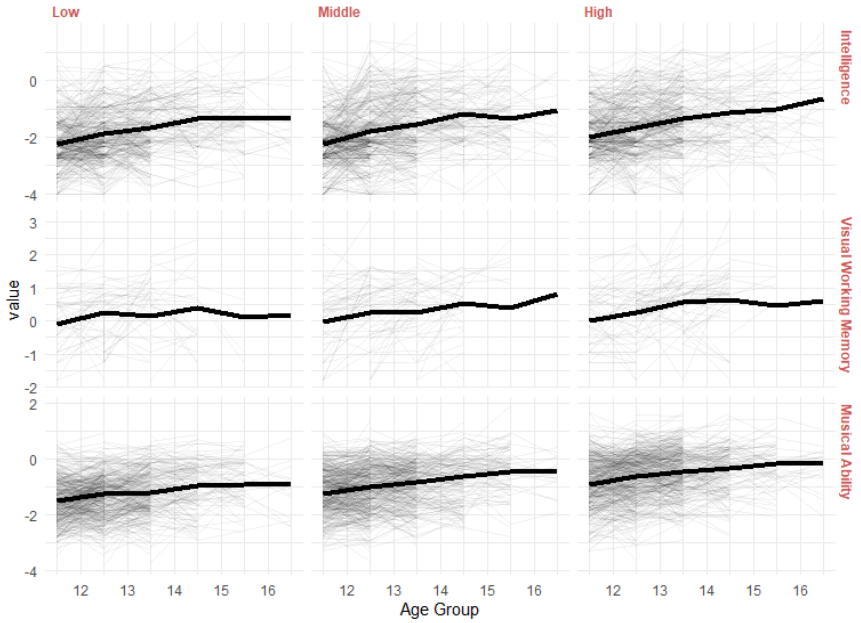


No linear growth assumed (latent curve model)



2. INDIVIDUAL DIFFERENCES IN INTRA-INDIVIDUAL CHANGE

Children with more musical training grow their abilities faster with age

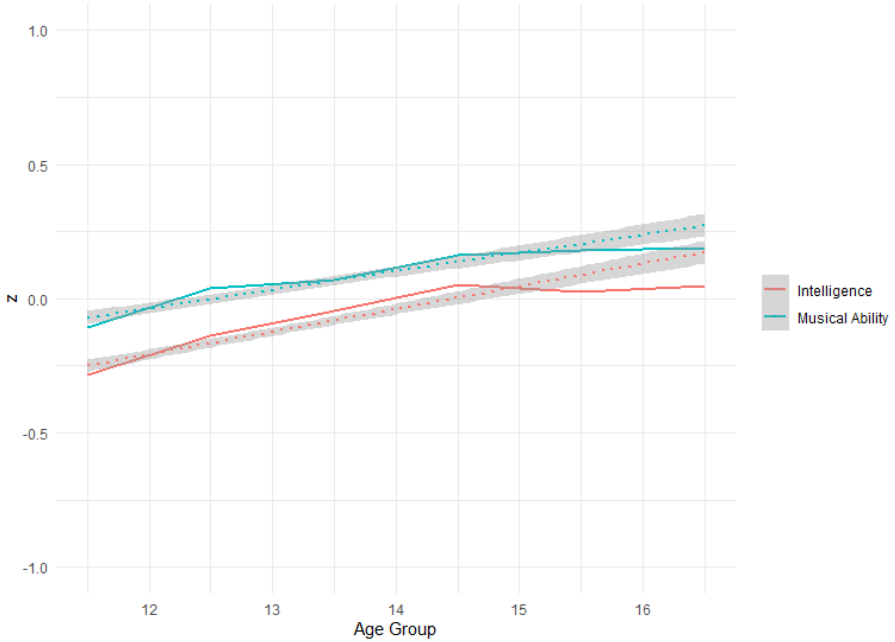


Variable	Predictor	beta	95% CI	p
Visual Working Memory	Age Group	0.09	[0.07, 0.12]	< .001
	Age Group x Musical Training	0.01	[0.00, 0.01]	< .001
Intelligence	Age Group	0.21	[0.19, 0.23]	< .001
	Age Group x Musical Training	0.01	[0.00, 0.01]	< .001
Musical Ability	Age Group	0.09	[0.07, 0.10]	< .001
	Age Group x Musical Training	0.02	[0.02, 0.02]	< .001

Effect on Musical Ability twice as large as on Intelligence and Working Memory

3. INTER-RELATION IN CHANGE

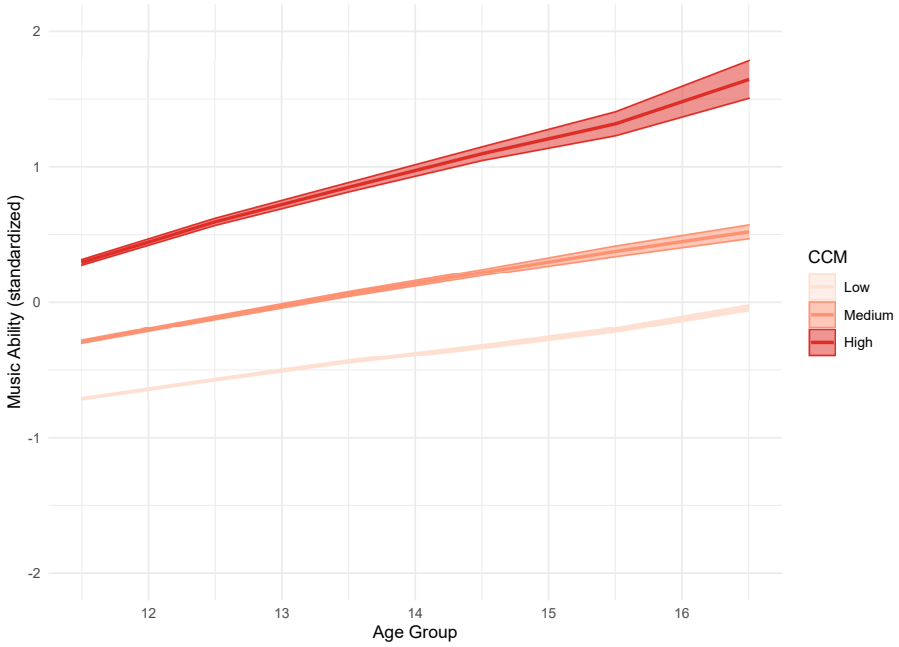
Intelligence and Musical Ability grow at different rates – Intelligence grows faster



Model	BIC	term	beta	95% CI
Single Growth Slope	33051	Intelligence + Music Ability	0.18	[0.17, 0.19]
Separate Growth Slopes	33037	Intelligence	0.21	[0.19, 0.23]
		Music Ability	0.15	[0.14, 0.17]

4. CAUSES OF INTRA-INDIVIDUAL CHANGE

Concurrent Musical Activity accelerates growth in cognitive and musical abilities



Variable	term	beta	95% CI	p	ΔR^2 marg.
Visual Working Memory	Age Group	0.120	[0.095, 0.145]	< .001	.0127
	Age Group x CCM	0.004	[0.002, 0.005]	< .001	
Intelligence	Age Group	0.249	[0.232, 0.267]	< .001	.0132
	Age Group x CCM	0.005	[0.004, 0.006]	< .001	
Melodic Discrimination	Age Group	0.153	[0.134, 0.173]	< .001	.0562
	Age Group x CCM	0.010	[0.009, 0.011]	< .001	
Mistuning Perception	Age Group	0.163	[0.142, 0.183]	< .001	.0451
	Age Group x CCM	0.008	[0.007, 0.009]	< .001	
Beat Perception	Age Group	0.225	[0.204, 0.247]	< .001	.0293
	CCM	0.097	[0.081, 0.112]	< .001	
Musical Ability	Age Group	0.163	[0.149, 0.177]	< .001	.0669
	Age Group x CCM	0.008	[0.007, 0.009]	< .001	

Effect on Musical Ability several times larger as on Intelligence and Working Memory

5. CAUSES OF DIFFERENCES IN INTRA-INDIVIDUAL CHANGE

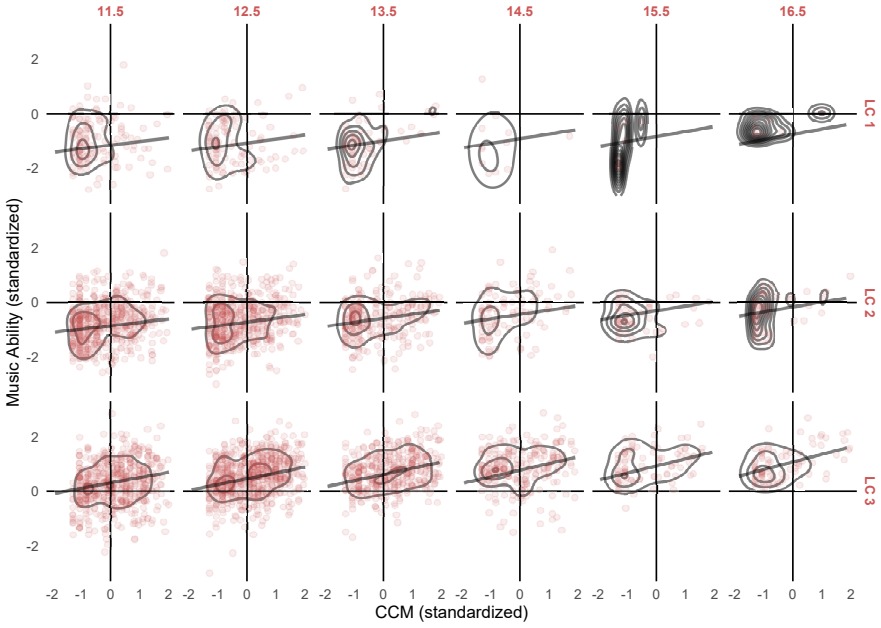
Step 1: Identify clusters of pupils that differ in absolute level and growth rate of ability

Step 2: Find predictors associated with clusters

GROWTH IN MUSICAL ABILITY

STEP 1: IDENTIFY CLUSTERS THAT DIFFER IN LEVEL AND GROWTH

LC3 ('musical potential'), LC2 ('little maturation growth'), LC1 ('catching up')

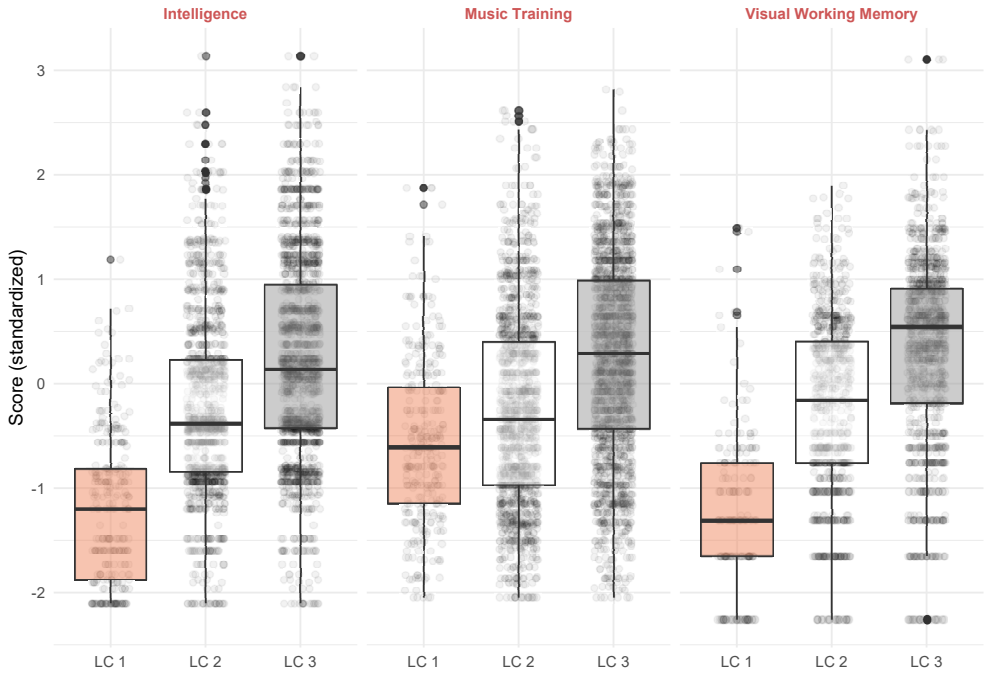


Class	Term	β	Std. Error	95% CI	Wald	p
LC1	Intercept	-2.429	0.303	[-3.023, -1.835]	-8.0	< .001
LC2		-2.037	0.566	[-3.146, -0.929]	-3.6	< .001
LC3		-1.473	0.247	[-1.957, -0.988]	-6.0	< .001
LC1	Age Group	0.137	0.024	[0.091, 0.183]	5.8	< .001
LC2		0.078	0.043	[-0.007, 0.163]	1.8	.073
LC3		0.154	0.017	[0.120, 0.189]	8.8	< .001
LC1	Age Group x CCM	0.011	0.003	[0.005, 0.017]	3.6	< .001
LC2		0.012	0.005	[0.002, 0.022]	2.3	.024
LC3		0.017	0.002	[0.013, 0.021]	9.2	< .001

Children in all 3 clusters benefit from concurrent musical activity

STEP 2: FIND PREDICTORS ASSOCIATED WITH CLUSTERS

Musical potential (LC3) is associated high Intelligence, Working Memory, and Musical Training



Class	Term	Beta	Std. Error	95% CI	Wald	p
LC3	Intercept	-1.619	0.607	[-2.809, -0.430]	-2.7	.008
LC1		-0.213	0.373	[-0.943, 0.518]	-0.6	.568
LC3	Intelligence	0.583	0.123	[0.342, 0.823]	4.7	< .001
LC1		-0.343	0.096	[-0.530, -0.155]	-3.6	< .001
LC3	Mean Musical Training	0.471	0.122	[0.232, 0.710]	3.9	< .001
LC1		-0.316	0.097	[-0.505, -0.127]	-3.3	.001
LC3	Visual Working Memory	0.287	0.170	[-0.046, 0.621]	1.7	.091
LC1		-0.654	0.106	[-0.861, -0.446]	-6.2	< .001

GROWTH IN INTELLIGENCE

THREE CLASSES OF LEVEL AND GROWTH OF INTELLIGENCE

Class	Term	Beta	Std. Error	95% CI	Wald	p
1	Intercept	-4.358	0.169	[-4.690, -4.027]	-25.8	< .001
2		-4.417	0.531	[-5.457, -3.377]	-8.3	< .001
3		-4.332	0.305	[-4.929, -3.735]	-14.2	< .001
1	Age Group	0.186	0.013	[0.160, 0.212]	13.9	< .001
2		0.132	0.044	[0.046, 0.218]	3.0	.003
3		0.278	0.023	[0.233, 0.322]	12.2	< .001
1	Age Group x CCM	0.004	0.001	[0.002, 0.005]	4.9	< .001
2		-0.002	0.002	[-0.006, 0.002]	-1.1	.286
3		0.004	0.001	[0.001, 0.006]	2.6	.008

LC3 (‘fast growth’)

LC1 (‘medium growth’)

LC2 (‘low level, low growth’)

⇒ Only LC3 and LC1 benefit from Concurrent Musical Activities

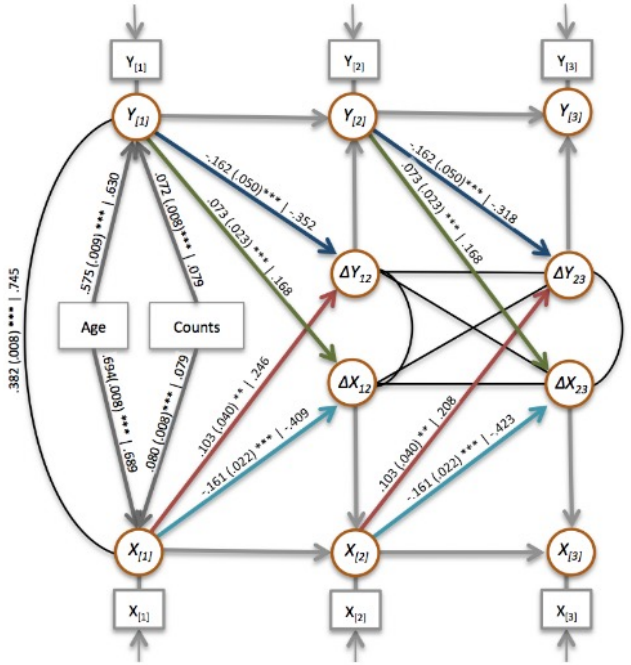
⇒Effect of musical activities is much smaller for intelligence compared to musicality ability

SUMMARY

- Musical and cognitive abilities grow over teenage years (cf. Gordon, 1986)
- Faster growth is associated with higher initial levels of musical training (static predictor, cf. Kragness et al., 2021)
- Rate of growth is similar for intelligence and musical abilities, but not identical (cf. Mosing et al., 2014)
- Growth is accelerated by concurrent musical activities (dynamic predictor, cf. Mosing et al., 2014; cf. Kragness et al., 2021)
- Acceleration effect is present for musical ability and intelligence (cf. Róman-Caballero et al., 2022), but stronger for musicality ability (i.e. stronger near transfer vs. weaker far transfer; cf. Bigand & Tillman, 2021)
- Variables associated with faster musical development ('musical potential') are working memory, intelligence, and musical training (cf. Ruthsatz et al., 2014)

IMPLICATIONS

- Evidence for development and validation of new talent model (TAD-Modell, Preckel et al. 2020; Müllensiefen et al., 2021; Labonde & Müllensiefen, 2022)
- Suggesting reciprocal influence between musicality and cognitive capacities across development (mutualism model)?



NEXT STEPS

- Replicate with more data, corrected data, and international data (Italy, Latvia, …)
- Replicate within structural equation model framework
- Link to development in other domains
- Development of evidence-based theory of musical development
- Take up the discussion with the community around the role of musical activity!