Music Education: Lessons from Brain Science

Prof Lauren Stewart
Music, Mind and Brain Group
Dept of Psychology
Goldsmiths

l.stewart@gold.ac.uk
www.musicmindbrain.com

The Brain that Changes

- "*Every man can, if he so desires, can become the sculptor of his own brain*" (Cajal, 1892)

- The change and growth of neurons and their connections through learning and experience

  - Development
  - Re-organization, post-injury
  - Learning and memory**

Skill-learning changes the brain

Maguire et al., (2000)

Music as a ‘Super-Skill’

” In no other human activity do memory, complex integration and muscular co-rdination surpass the achievement of the skilled pianist”

(Homer Smith, 1895 - 1962).

Music as a 'Super-Skill'

Plan and execute complex motor sequences

Co-ordinate between two or more sets of effectors

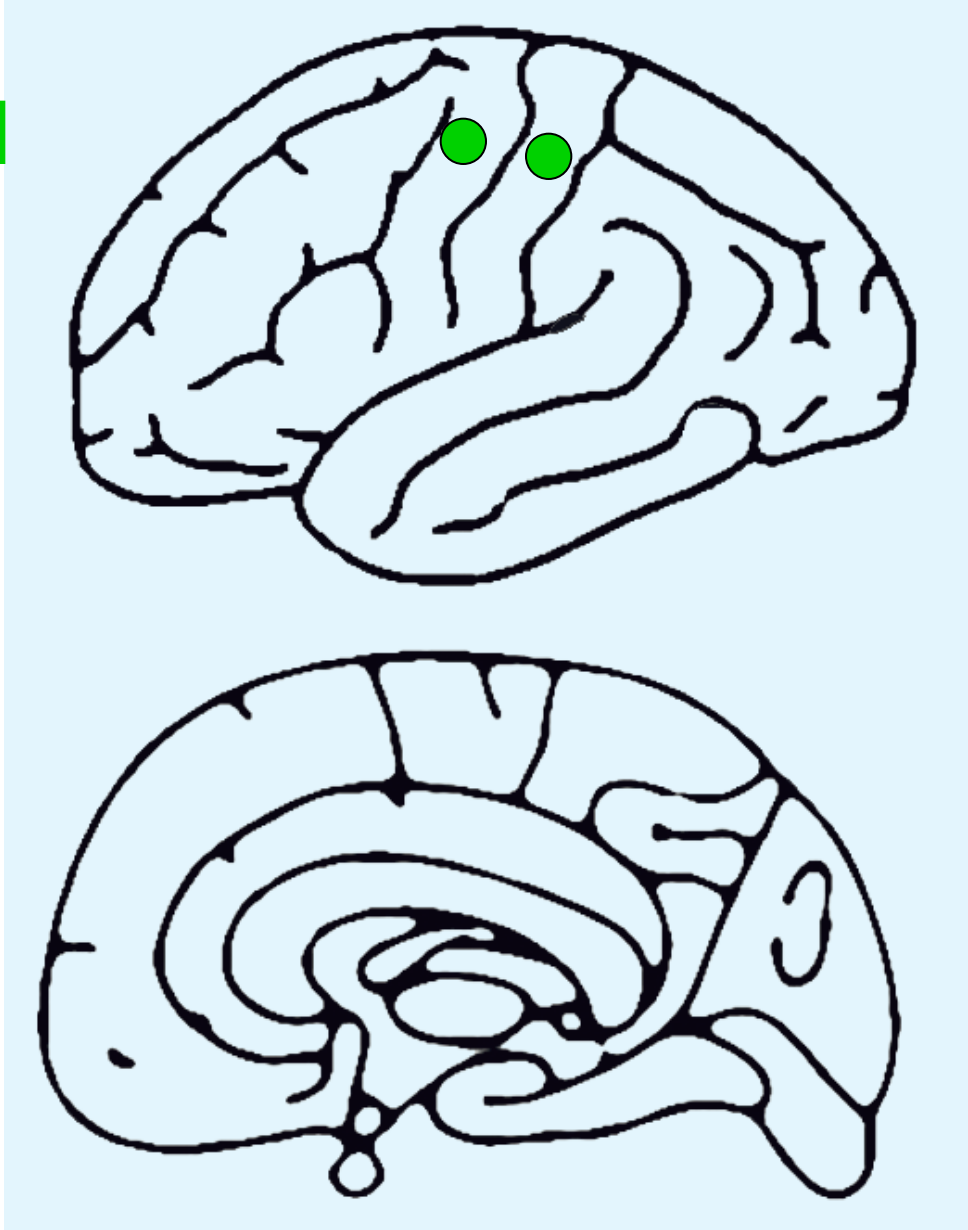
Integrate information across different sensory modalities

Monitor performance for errors

Convert from visual symbols to complex motor programs

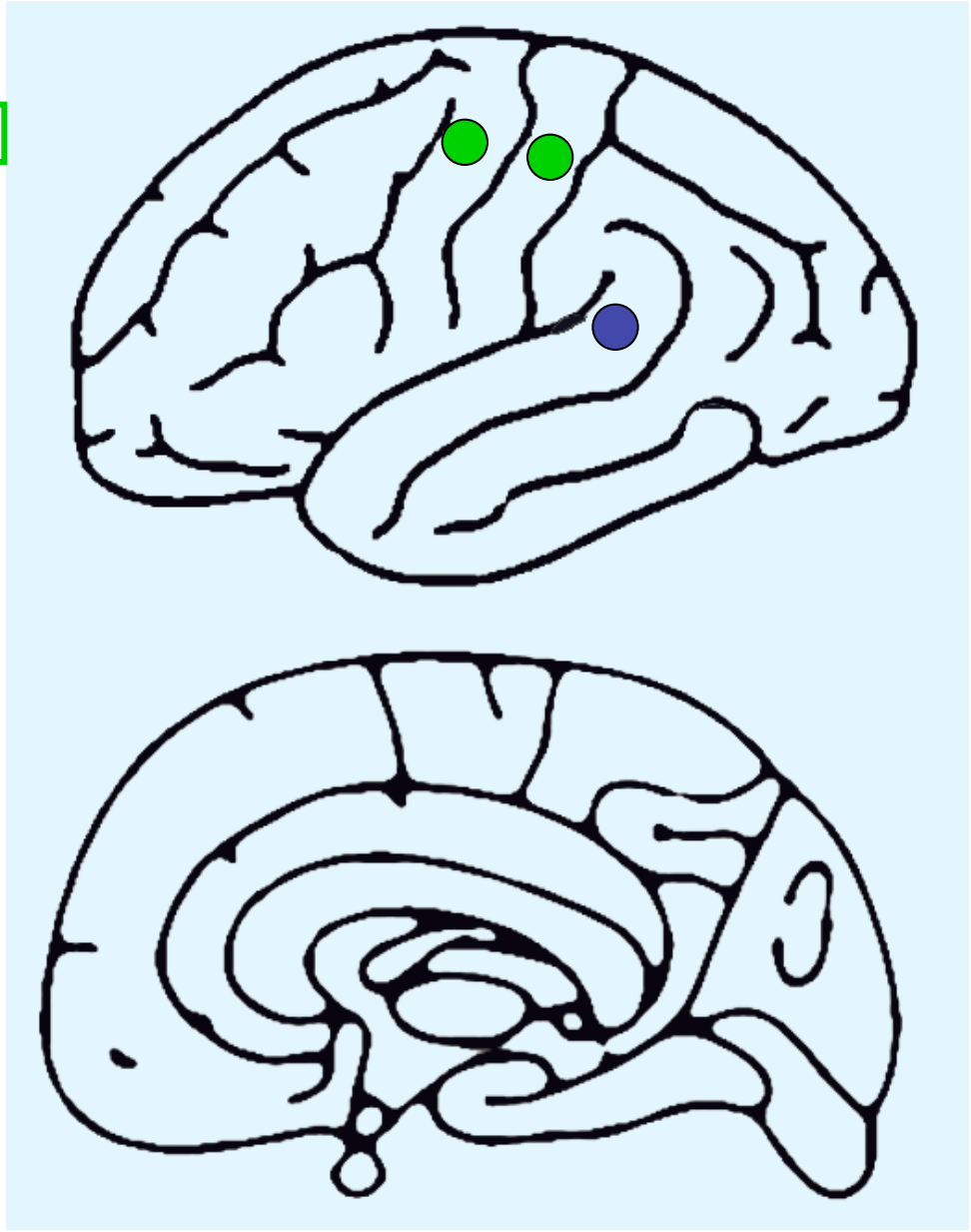
<u>Practice is intense, prolonged and typically from an early age</u>

FINE FINGER CONTROL



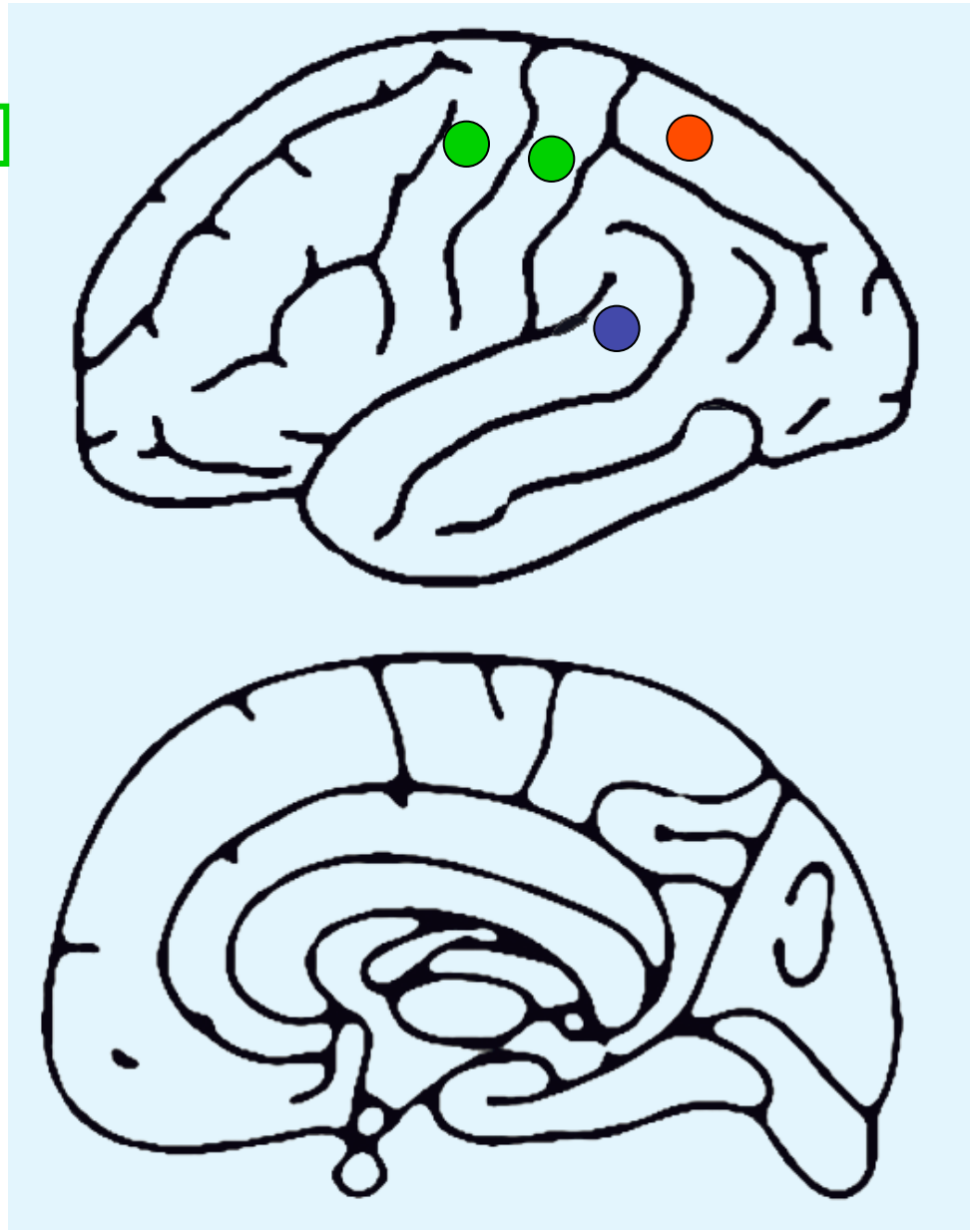
Stewart (2008), *Clinical Medicine*

FINE FINGER CONTROL



AUDITORY PROCESSING

FINE FINGER CONTROL



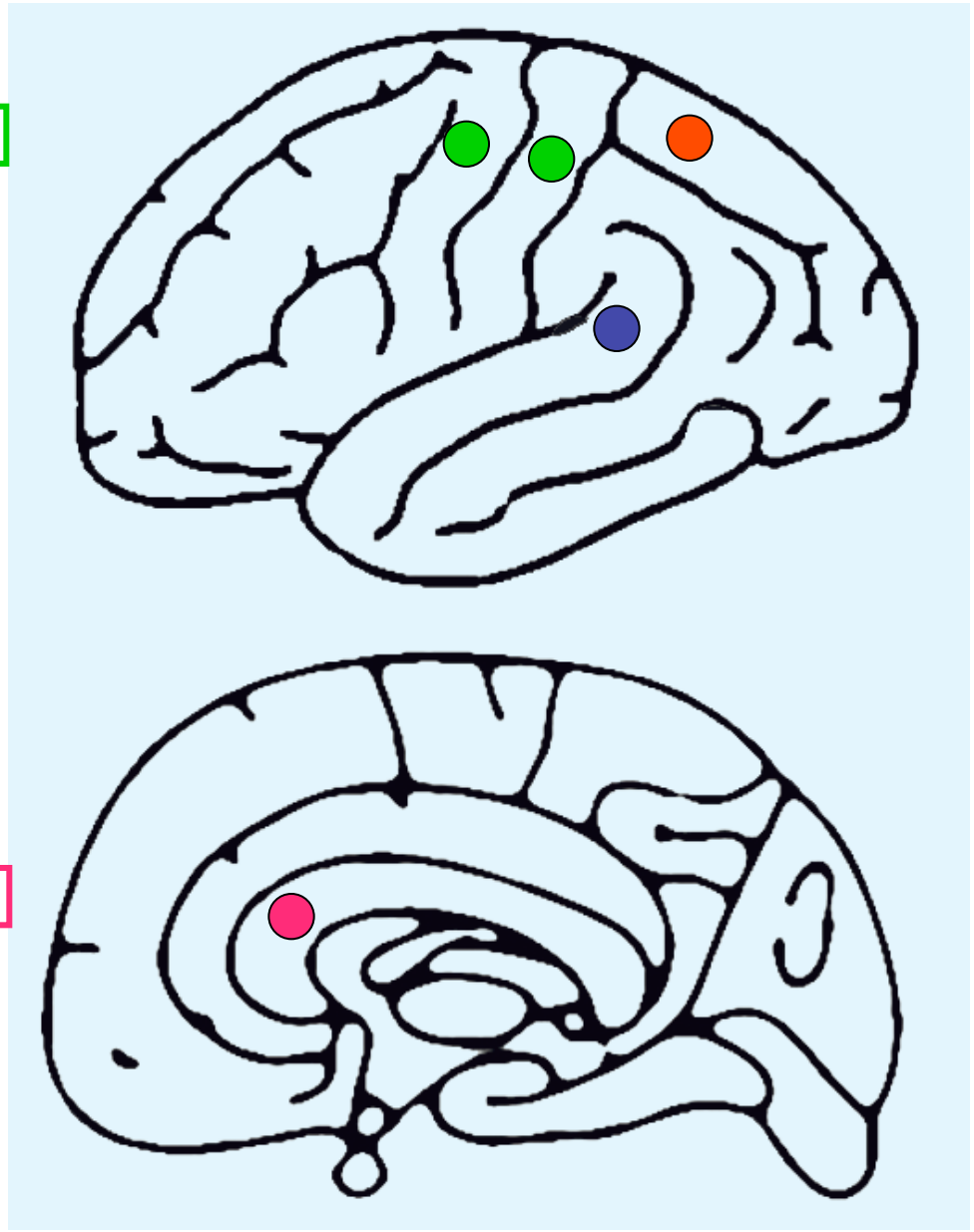
VISUOSPATIAL PROCESSING

AUDITORY PROCESSING

FINE FINGER CONTROL

VISUOSPATIAL PROCESSING

AUDITORY PROCESSING



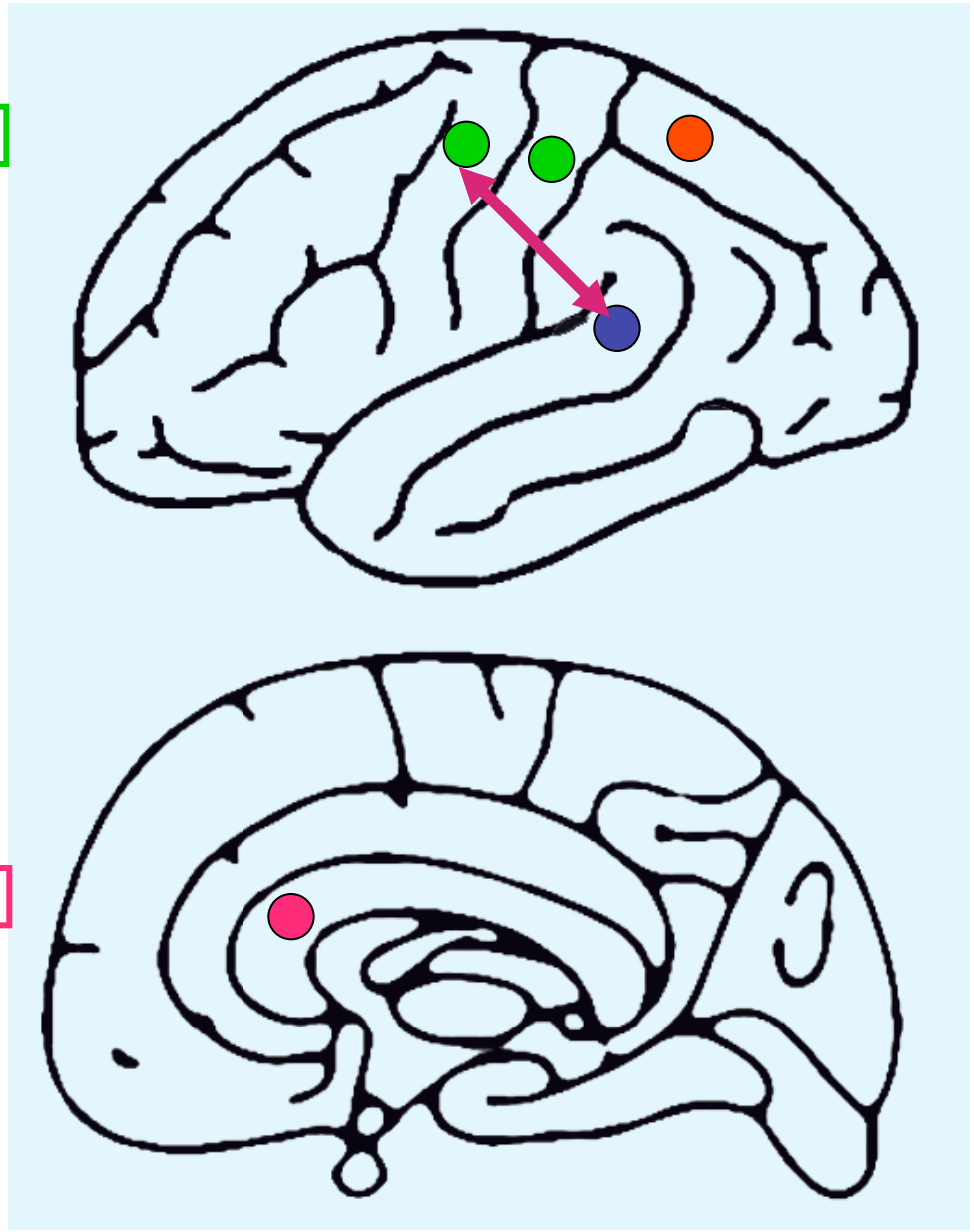
HEMISPHERIC CONNECTIVITY

FINE FINGER CONTROL

VISUOSPATIAL PROCESSING

AUDITORY PROCESSING

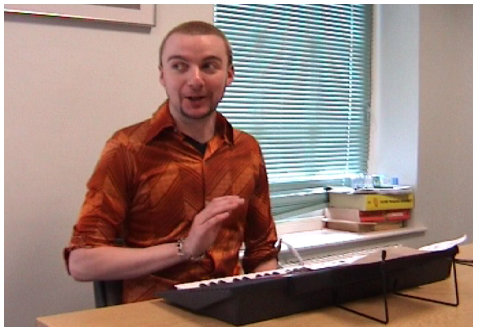
AUDIO-MOTOR INTEGRATION

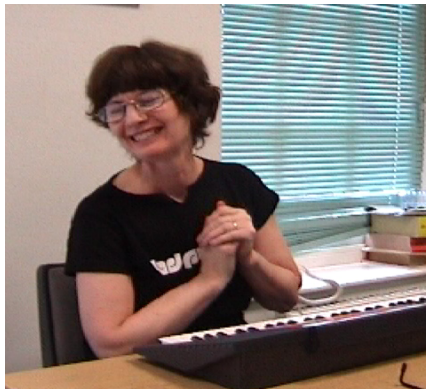


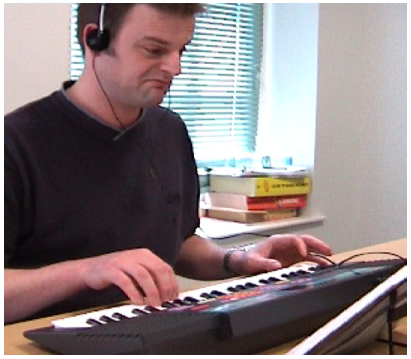
HEMISPHERIC CONNECTIVITY

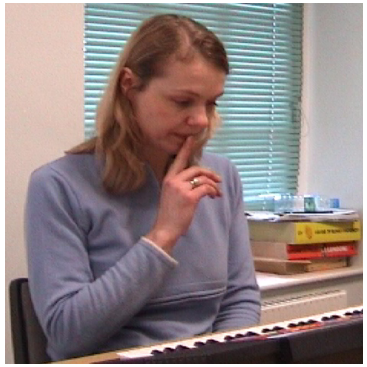
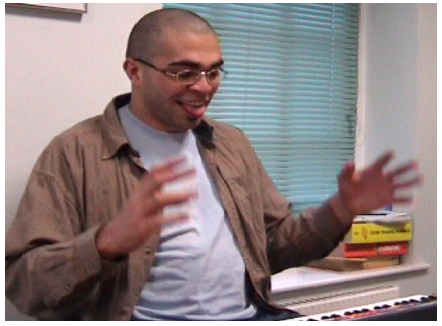
Musical Literacy Acqusition







A Cognitive Measure of Learning

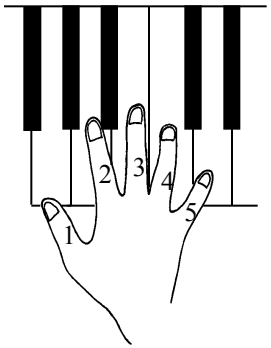
XXX RED BLUE

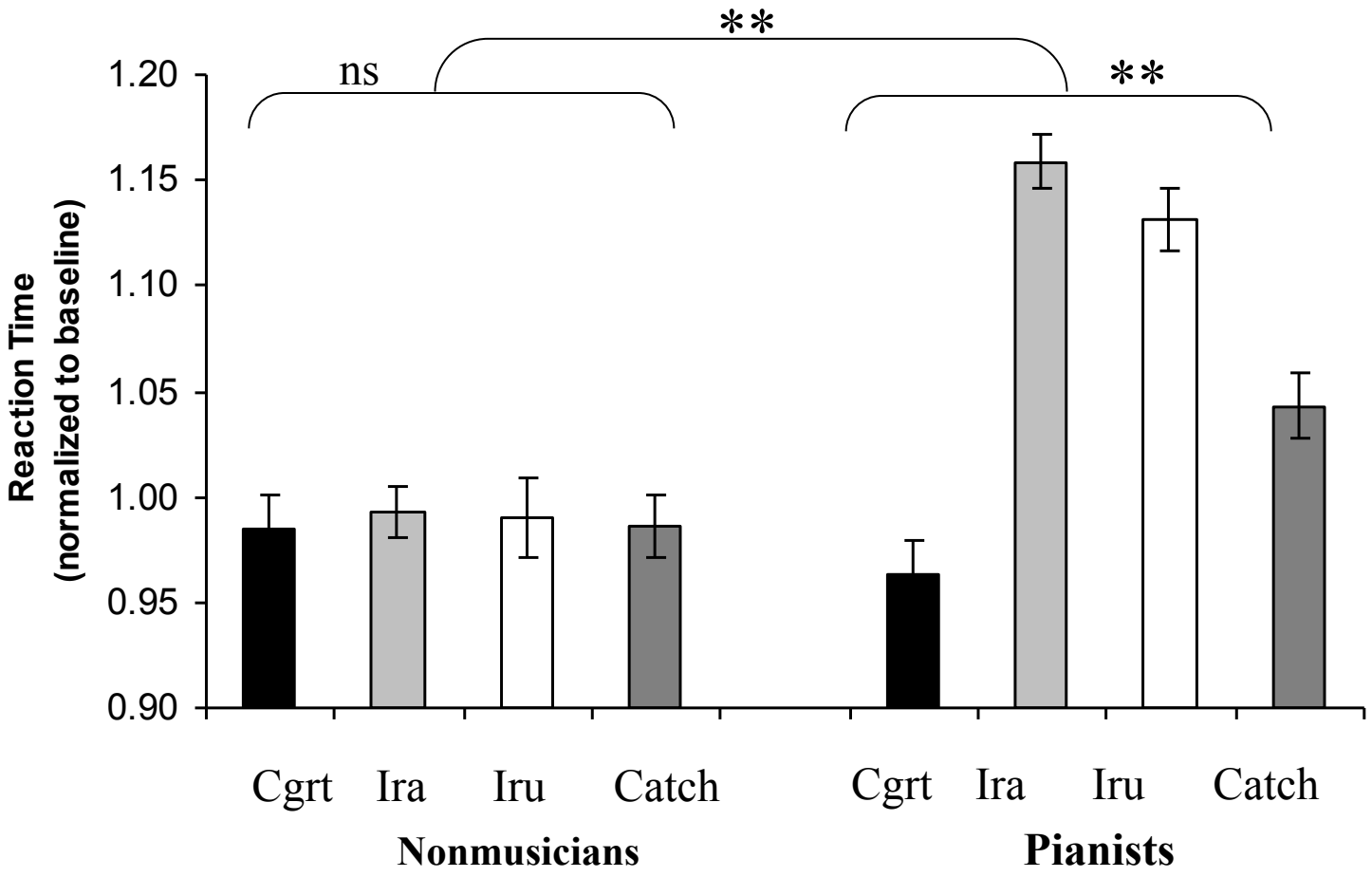
baseline

congruent

incongruent no rule

incongruent rule





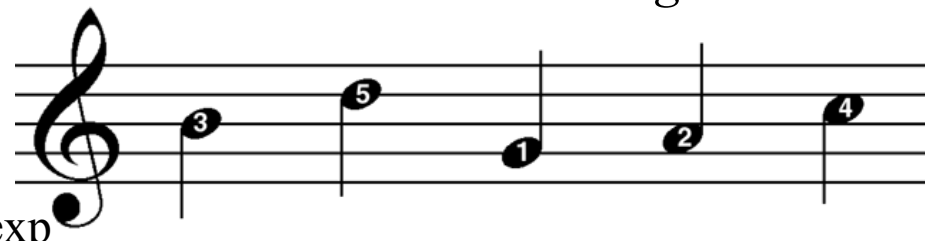
Stewart, Walsh & Frith (2004), *Perception and Psychophysics*

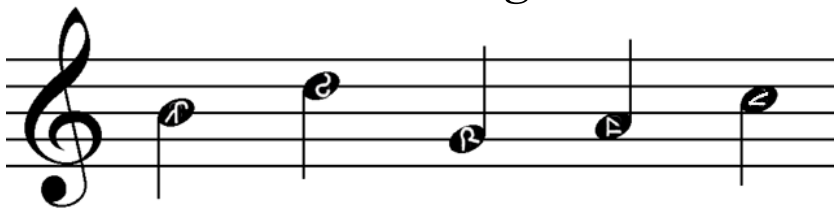
MELODY CONDITION

Pre-training

Post-training

exp





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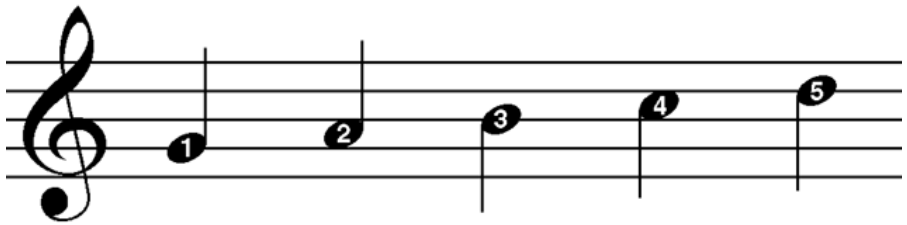
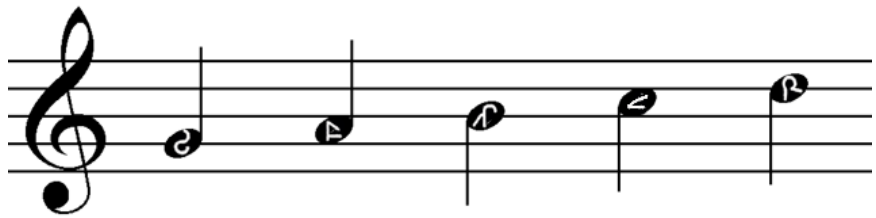
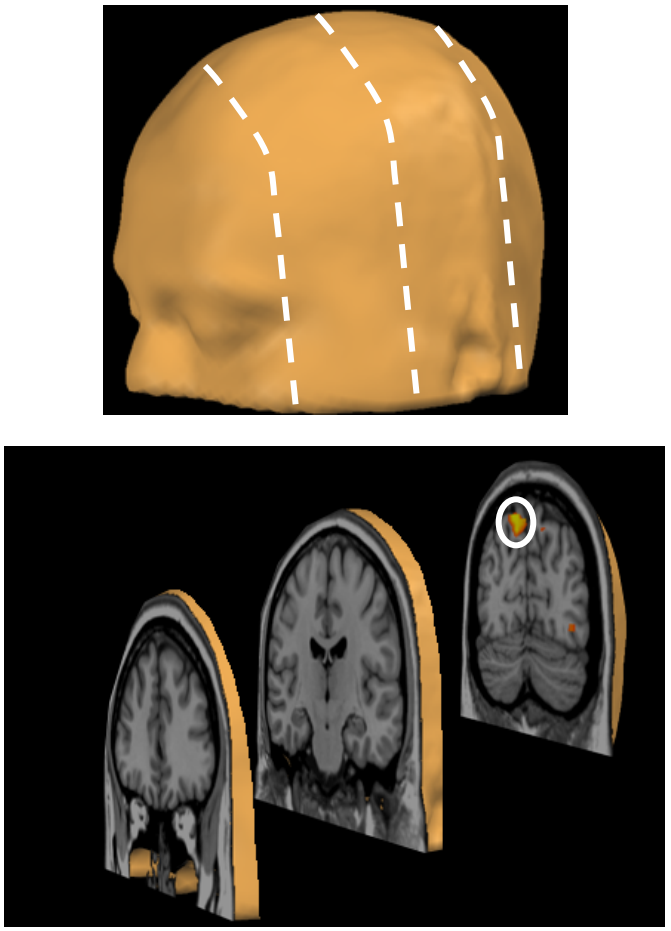






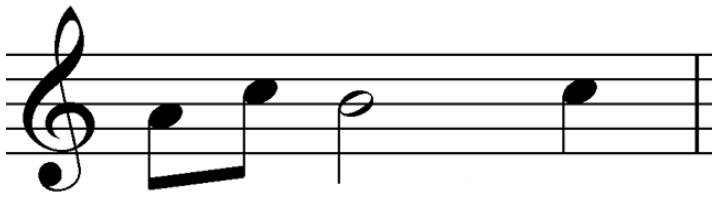
Stewart et al. (2003), *Neuroimage*

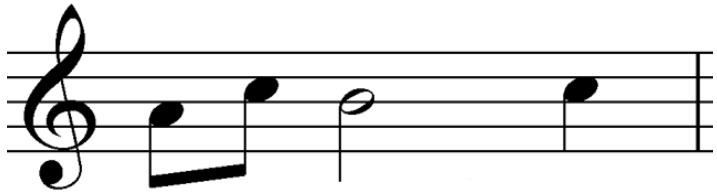
IMPLCIT READING CONDITION

Pre-training

Post-training

exp





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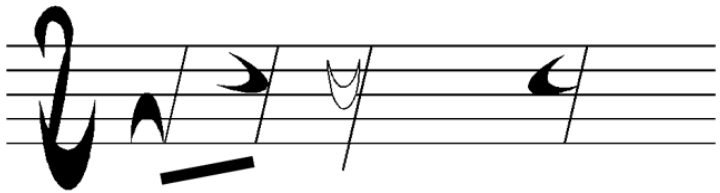
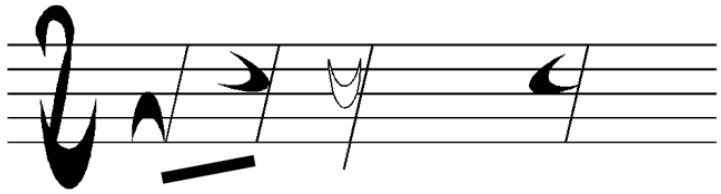
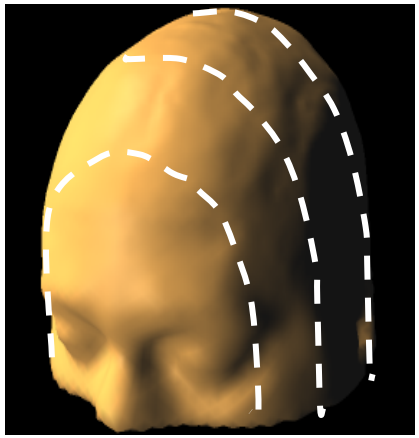
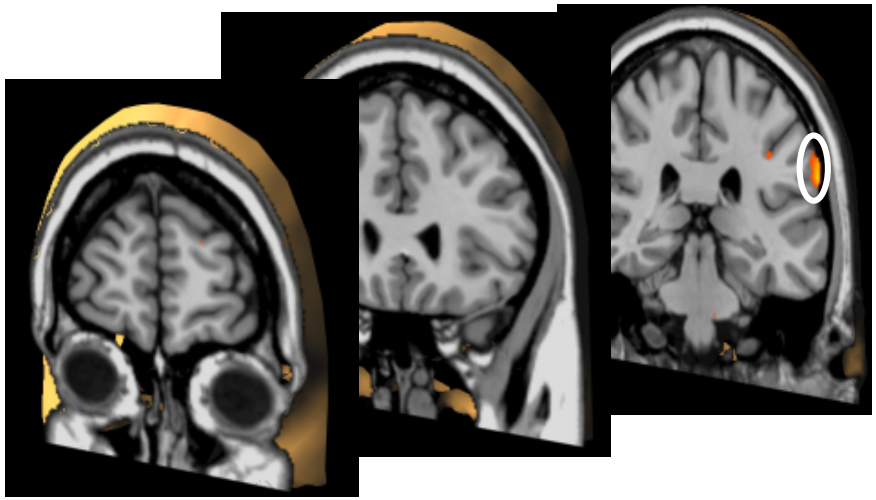








Stewart et al. (2003), *Neuroimage*

Musical literacy changes the brain

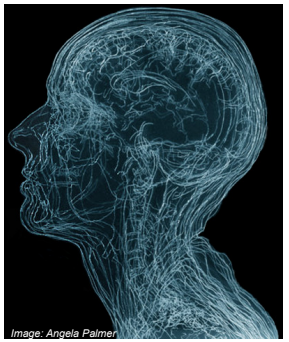
Obligatory decoding of notational system

Involvement of motor planning

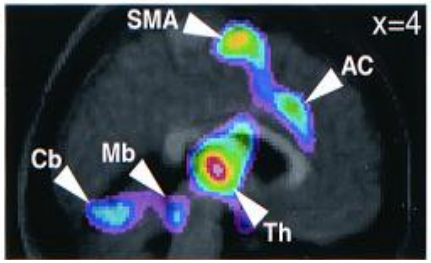
3 months only; adults

Expertise as Listeners

- Construction process



- Pattern seeking



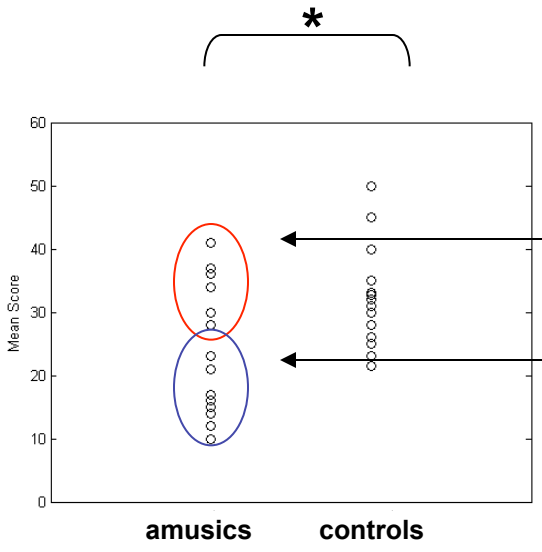
- Learning the rules

Tone Deafness and Musicality?

"Music, I regret to say, affects me merely as an arbitrary succession of more or less irritating sounds. Under certain emotional circumstances I can stand the spasms of a rich violin, but the concert piano and all wind instruments bore me in small doses and flay me in larger ones." (Nabakov)

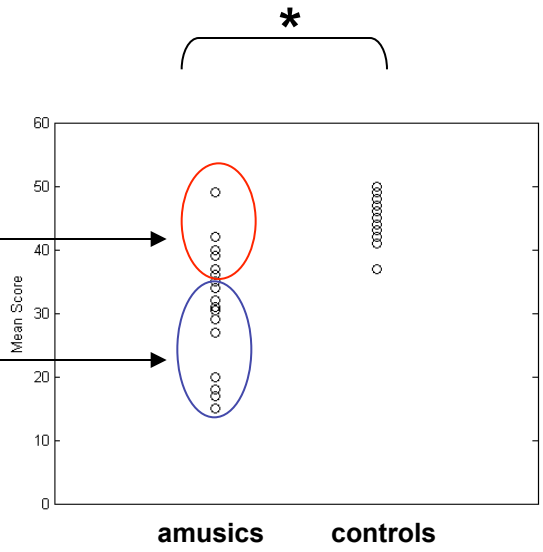
"I used to go to concerts – it was the thing to do, but I didn't enjoy it really. My husband asked me what music I liked – I said "loud music". I married him and he played Mozart. I said "turn off that awful noise". We went to operas and I slept through several of them – he really nagged me. We got divorced." (Participant)

Everyday Uses



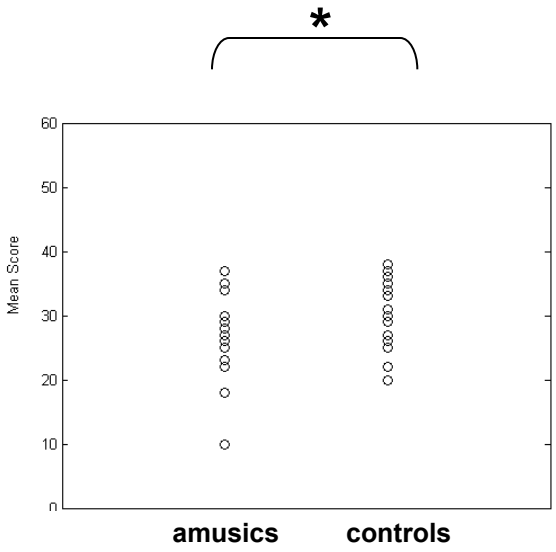
Bath
Exercising
Reading
Study/Work
Chores
Driving
Getting Up
Bedtime
Meal
Walk

Psychological Functions



Memories
Shiver
Match Mood
Catharsis
Relax
Uplift
Sadden
Comfort
Motivate
Spiritual

Public Places

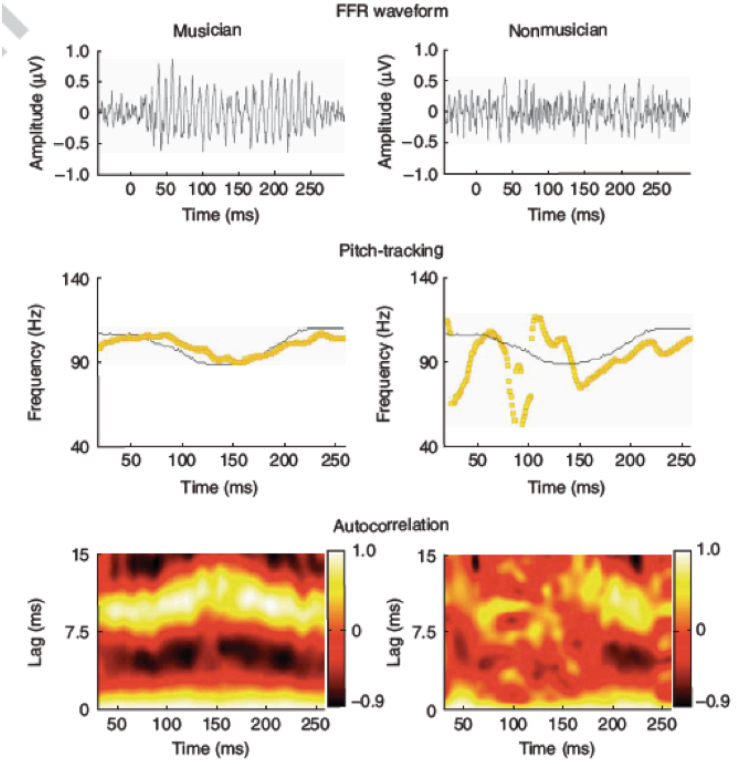


Party
Eating Out
Cinema
Elevator
Doctors
Shopping
Living Area
Buskers
Phone
Public Transport

McDonald, C. and Stewart, L.(2008) *Music Perception*

Transfer Effects

- Near transfer:
  - *Speech processing (Kraus, 2014)*
  - at the level of the brainstem, the representations of the sounds are more elaborated and more accurate in musicians than in non-musicians.
  - Mechanism: Descending auditory pathway



- Far Transfer:
  - *Reading (Anvari et al., 2002; Butzlaff, 2000)*
  - *Verbal recall (Jakobsen et al., 2003)*
  - *Mathematical and spatial skills (Forgeard et al., 2008; Hetland, 2000; Vaughn, 2000)*
  - *Academic achievement at university level (Schellenberg, 2006)*
- Mechanisms: Executive function, polymodal integration)

Table 1. Review of previous RCTs assessing child cognitive development and music lessons.

Notes on Main or Ancillary Effects	Music group outperforms control group on overall test after 2 years of training in a direct comparison of scores (Tukey test, $p=.05$), but not after 1 or 3 years.	Music group shows significantly larger increase in performance than control group on 1 of 5 subtests (Bead Memory; $F(1,43)=6.29$, $p=.016$).	Combined keyboard and voice group shows significantly larger increase in *g* than combined drama and control group ($t(130)=1.99$, $p=.049$, $d=.184$[3]).	Music group has significantly fewer errors on 1 of 3 subsets of the reading battery (Tukey test, $p<.05$[2])	Music group shows significant increase in performance on 1 of 2 subtests (Vocabulary; $F(1,62)=11.37$, $p=.0013$, partial $\eta^2=.33$), visual art group does not.
Citation Count[1]	167	124	374	183	59
Correction for Multiple Comparisons?	Yes	No	No	No	No
Overall Cognitive Effect?	No	No	Yes	No	No
Additional Measures Administered	Musical Aptitude Profile [49]; Bruininks-Oseretsky Test of Motor Proficiency [50]; Canadian Achievement Test 2 [51]; Coopersmith Self-Esteem Inventories [52]	Young Child Music Skills Assessment (designed by authors)	Kaufman Test of Education Achievement [54]; Behavioral Assessment System for Children [55]	Portuguese European Reading Battery [59]; tests of speech and pitch discrimination [60] with EEG recording	Executive function "go/no-go" task (designed by authors) with EEG recording
Primary Measure of Child Cognition	*g* via Developing Cognitive Abilities Test ([12], 3 of 3 subtests administered)	*g* via Stanford-Binet Intelligence Scale ([13], 5 of 15 subtests administered)	*g* via Wechsler Intelligence Scale for Children ([10], 12 of 12 subtests administered)	*g* via Wechsler Intelligence Scale for Children, Portuguese adaptation ([58], 10 of 10 subtests administered)	*g* via Wechsler Preschool and Primary Scale of Intelligence ([13], 2 of 7 subtests administered)
Training Length	52.5 hours over 90 weeks	37.5 hours over 30 weeks	28 hours over 36 weeks	55 hours over 24 weeks	15 hours over 4 weeks
Comparison Group Type	No-treatment control	No-treatment control	Weekly group drama lessons or no-treatment control	Weekly group painting lessons	Daily computer-based group visual art activities
Music Curriculum	Weekly private piano lessons with "traditional curriculum"	Weekly Kindermusik [38] group classes (sometimes includes parents)	Weekly group "standard" piano lessons or Kodály [53] voice lessons	Weekly group classroom music in Kodály, Orff, and Wuytack methods [57]	Daily computer-based group music listening activities
Age of Children at Testing (in years)	12[2]	4.9–6.7[2]	7.08 (.237)	8.82 (.375)	5.40 (5.65)
Final Sample Size	67	66	132	32	48
Initial Sample Size	117	71	144	37	64
Study	[5]	[6]	[7]	[8]	[9]

Note. Studies are reviewed in chronological order, from 1999 [5] to 2011 [9]. Standard deviations, where available, are in parentheses. This table was completed with the generous assistance of the authors of each of the above papers, who helped clarify a variety of relevant statistics from their work.

[1]As of November 2013, from Google Scholar.

[2]Value represents an estimate; exact value was not available from the author(s).

[3]The effect size reported in [7] is $d=.35$, a figure calculated in terms of the pooled standard deviation of children's increases in IQ score. However, the relevant effect size is in terms of the standard deviation of the test itself, not that of gain scores (see, e.g., [56]). Thus, we recalculated the effect size using the standard deviation of the WISC-III's reference population (fifteen IQ points [10]) and report this figure above.

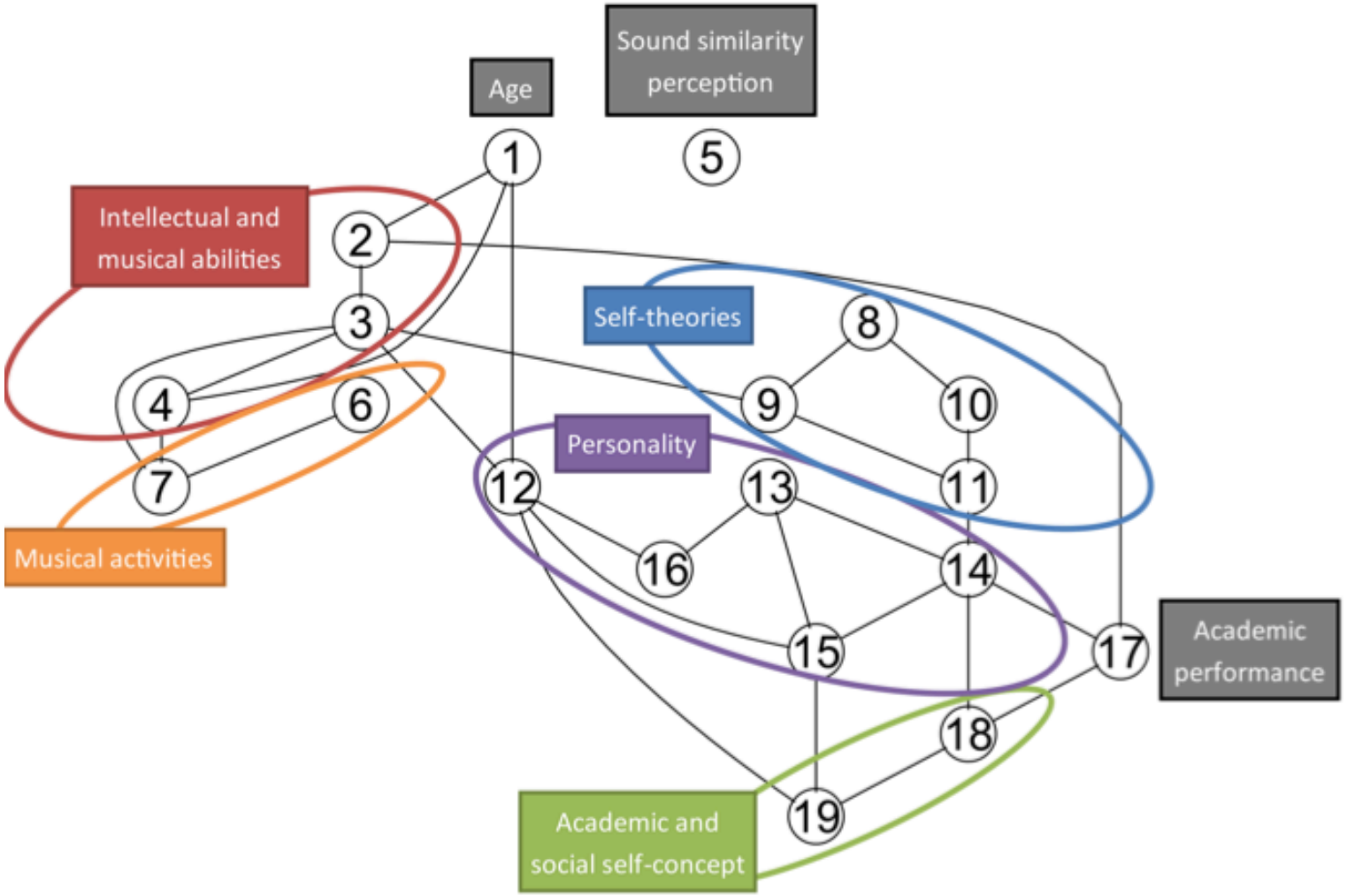
doi:10.1371/journal.pone.0082007.t001

5. *Costa-Giomi E (1999) The effects of three years of piano instruction on children's cognitive development. J Res Music Educ 47: 198–212.*
6. *Bilhartz TD, Bruhn RA, Olson JE (1999) The effect of early music training on child cognitive development. J Appl Dev Psychol 20: 615–636.*
7. *Schellenberg EG (2004) Music lessons enhance IQ. Psychol Sci 15: 511–514.*
8. *Moreno S, Marques C, Santos A, Santos M, Castro S, et al. (2009) Musical training influences linguistic abilities in 8-year-old children: more evidence for brain plasticity. Cereb Cortex 19: 712–723.*
9. *Moreno S, Bialystok E, Barac R, Schellenberg EG, Capeda NJ, et al. (2011) Short-term music training enhances verbal intelligence and executive function. Psychol Sci 22: 1425–1433.*

Thorny issues

- Sensitive, well controlled studies are rare

- Its complex:
  - Cognitive ability & academic achievement ?
  - Personality – is it fixed?
  - Self theories – ideas about how much nurture can play a role



Mullensiefen, Harrison, Caprini and Fancourt, in prep

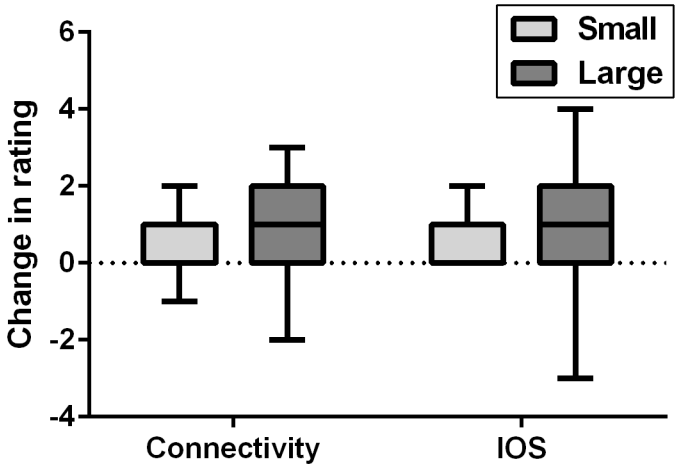
What are they missing?

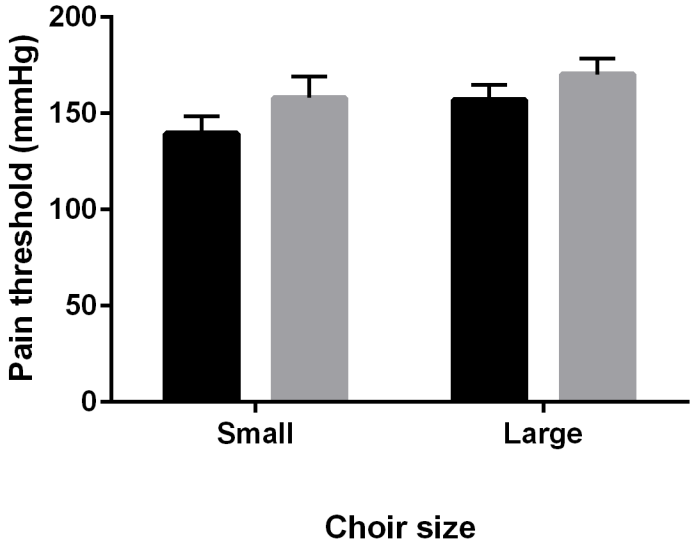
Getting specific

- Communication/attachment (early years)
- Physiological regulation (MANDARI)
- Mood and Emotion (Tuned in Teens)
- Social bonding (Popchoir)
- Cognitive and Physical Rehabilitation (Stroke)

Music for Social Bonding

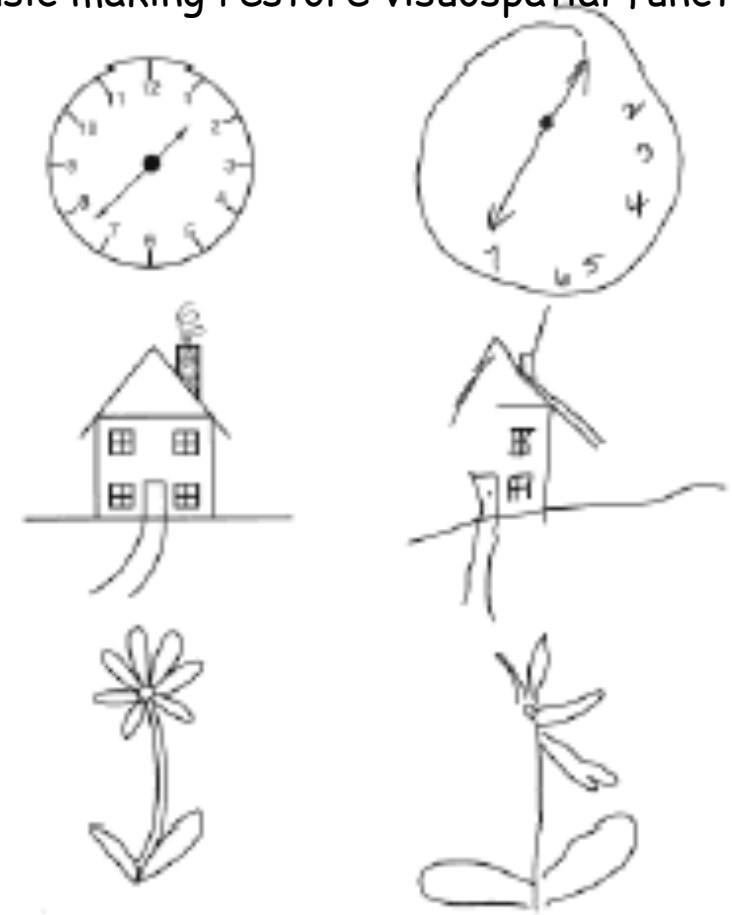
- Question: is music making a potential mechanism that allows for large social groups?

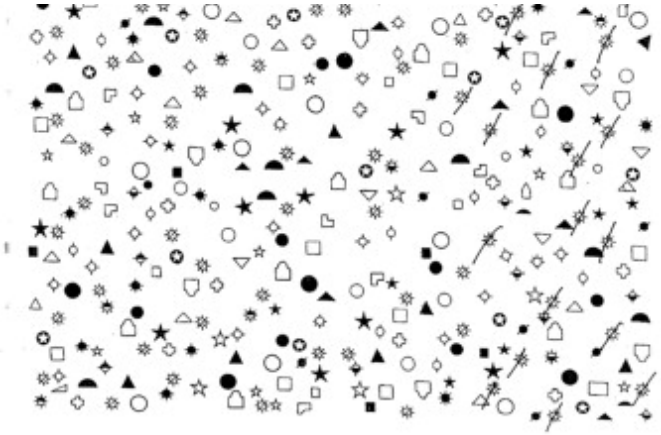




Music for Cognitive Rehabilitation

- Question: can music making restore visuospatial function in stroke patient with neglect?





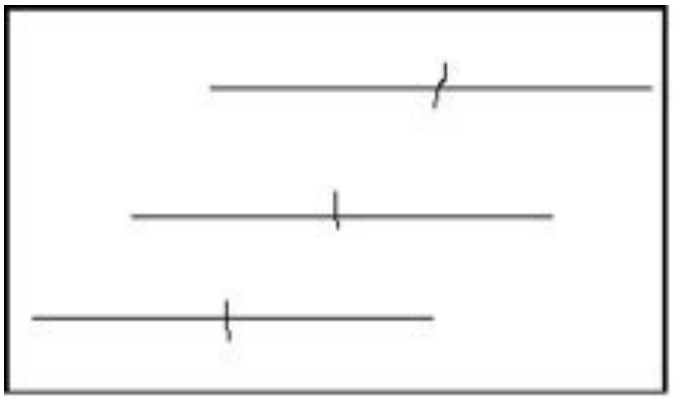


Table 2 | Summary of results.

Test		Unit	Patient 1				Patient 2			
			Average pre	**Average post**	**Mean baseline**	**Follow-up**	**Average pre**	**Average post**	**Mean baseline**	**Follow-up**
Mesulam shape	Left	Omissions	**24**	**13**	**26**	**11**	**5**	**2**	**8**	**1**
	Total	Omissions	**27**	**13**	**27**	**13**	**6**	**2**	**8**	**1**
BIT star	Left	Omissions	8	6	**18**	**8**	5	3	3	1
	Total	Omissions	10	7	**19**	**10**	6	3	5	1
TAP	Left	Omissions	21	20	19	19	21	21	21	20
	Total	Omissions	29	27	30	23	22	22	22	24
Line bisection[a]		mm	11	14	10	17	20	10	19	16

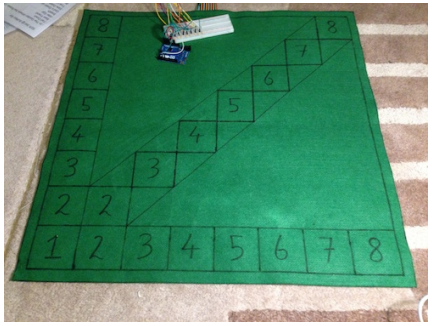
Bold typeface indicates a significant improvement.

[a]*Average rightward deviation from the true center from three separate 180 mm lines during each testing session.*

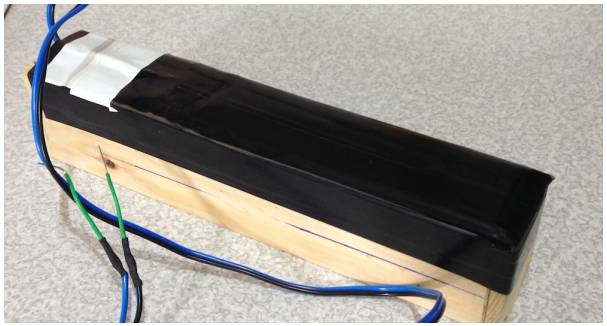
Bodak et al., 2013

Music for Physical Rehabilitation

Musical Stress Balls



Sound Board



Electronic chime bar

Suggestions for the Classroom

- Pay attention to music's temporal dimension: attention, familiarity, differences in listening histories; where are the 'tingle' moments?
- Repetition breeds liking
  - Expose children to a piece 'incidentally', pair this with more focussed listening
- Allow children to move and experience it in their own terms
- Use music as a vehicle to learn about literacy, mathematics, science, acoustics, history
- Abandon notions of musical talent: motivation plays a greater role than predisposition
- Use music to promote intergenerational and intercultural understanding

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l.stewart@gold.ac.uk