Music and Cognitive Flexibility – a case of limited transfer?

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Introduction

The complexity of information processing when listening to and making music has encouraged research focusing on the possible transfer effects of music training. The basic question is whether skills that are acquired by music training also lead to improved performance in tasks that have not been directly trained, such as cognitive tasks in nonmusical domains. Within this line of research, a distinction is made between near transfer (e.g., transfer from music training to auditory working memory) and far transfer (e.g., transfer to general intelligence).

One of the areas for which transfer effects have been proposed is cognitive flexibility, which is part of the executive functions. In the musical domain, cognitive flexibility is required e.g., when the musician must adapt to switches between different clefs or keys in reading music notation. Experimentally, cognitive flexibility is usually measured by asking participants to switch between different cognitive tasks. Switch costs (slower/more error-prone performance when asked to switch the task) are obtained as an index of cognitive flexibility. Smaller switch costs reflect better flexibility.

An interesting music-related switching task was introduced by Slama et al. (2017, see Fig. 1 and Method section), who showed influences of music training on this non-musical task suggesting transfer (but see Gade & Schlemmer, 2021).

Aims

On order to investigate the influence of music training on cognitive flexibility, we designed an experiment in which participants solved both a music-related task modeled after Slama et al. (2017) and a non-musical task. We expected music training to influence the performance in the music-related switching task, but not in the non-musical switching task, corroborating former work.

Method

In the music-related task, participants were presented with a cue (either a violin or a bass clef) on a computer screen for 250 ms. After a cue-target interval of 1600 ms, the target stimulus (musical note in letter notation) and two accompanying stimuli (musical notes in staff notation in violin clef and bass clef) were presented. Participants had to indicate the position of the matching stimulus by pressing either *S* or *L* on the computer keyboard. The non-musical task was designed likewise, with “>“ or “<“ as cue and numbers as target/accompanying stimuli (see Fig. 1). Six musical notes (C, D, E, F, G, A) as well as six numbers were used for the two tasks. Participants completed 24 practice trials and 102 test trials in each task. Task sequence was random within and between blocks. Errors and reaction times were collected.

In addition to the switching task, participants filled out the musical training scale (MT) of the Gold-MSI (Müllensiefen et al., 2014). Our sample consisted of two groups:

Music group (MU)		Control group (KO)	
N = 52	18-35 years	N = 19	18-50 years
23 ♀, 26 ♂, 3 ⚥	ø 36.04 Gold-MSI (MT)	5 ♀, 14 ♂	ø 21.8 Gold-MSI (MT)

Since pretests suggested that the music-related task was too difficult to be solved by non-musicians, our experiment was run with both blocks in the music group, while the control group solved only the non-musical task.

Results

Music Group: A linear mixed effects model with transition (switch vs. repetition) and task (musical vs. non-musical) as fixed factors on level 1 and Gold-MSI training scale score (MT) as factor on level 2 was calculated, with participant as random factor. Fig. 2 shows the results of the music group.

Effect	df	F	p	Interpretation
Task transition	2, 53.5	18.947	< .001	significant switch costs
Task	1, 57.9	13.712	< .001	musical task is more difficult than non-musical
Score	1, 57.8	14.449	< .001	higher MT → shorter RT
Task transition * Task	1, 52.2	1.818	0.183	switch costs are comparable across tasks
Task transition * MT	1, 50.5	0.010	0.921	no influence of MT on switch costs
Task * MT	1, 57.8	9.231	0.004	only musical task is influenced by MT
Task transition * Task * MT	1, 50.5	1.661	0.203	no difference in switch costs between tasks depending on MT

Non-musical task: In order to compare both groups in their performance on the non-musical task, we calculated proportional switch costs for each participant (RT switch / RT repeat). Proportional switch costs were compared with a between-group t-test. The group difference (music vs. control) was not significant (m_{MU} = 1.072, m_{KO} = 1.078, t(22.216) = 0.225, p = .824). Fig. 3 shows the results for this comparison.

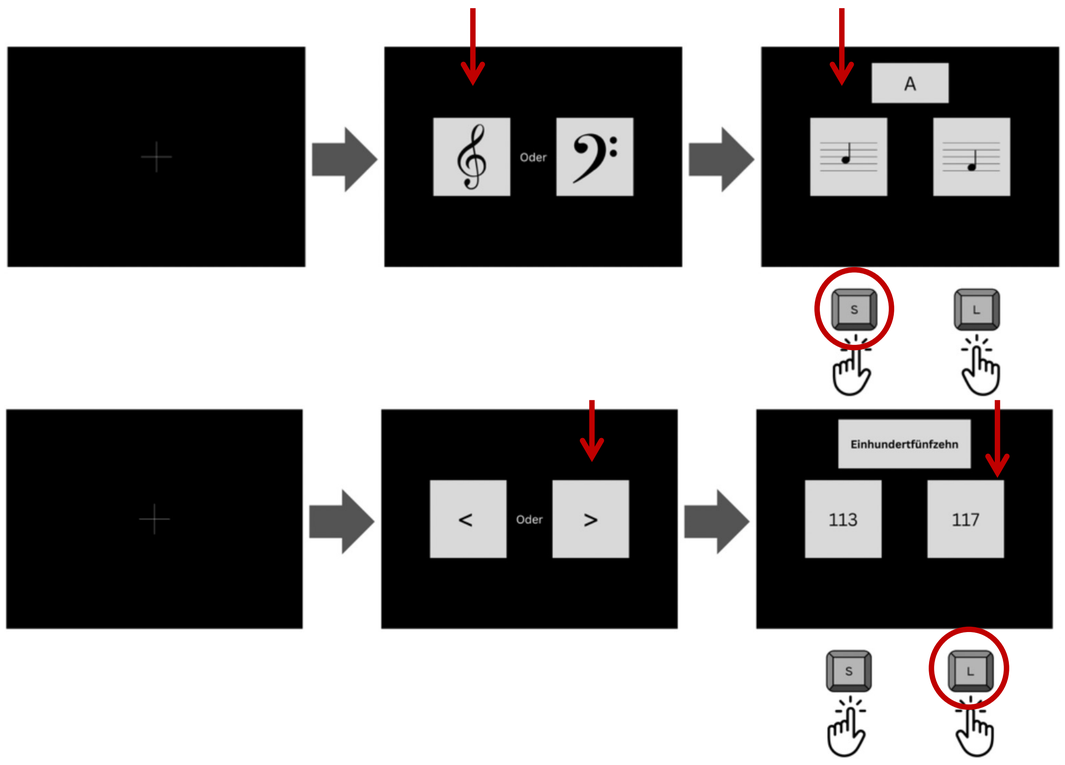

Fig. 1: Switching task musical (upper part) and non-musical (lower part). Participants must attend to the cue for each trial and answer accordingly. For example, if the cue is a violin clef in the musical task, they have to decide which of the two notes represents an A in a violin clef.

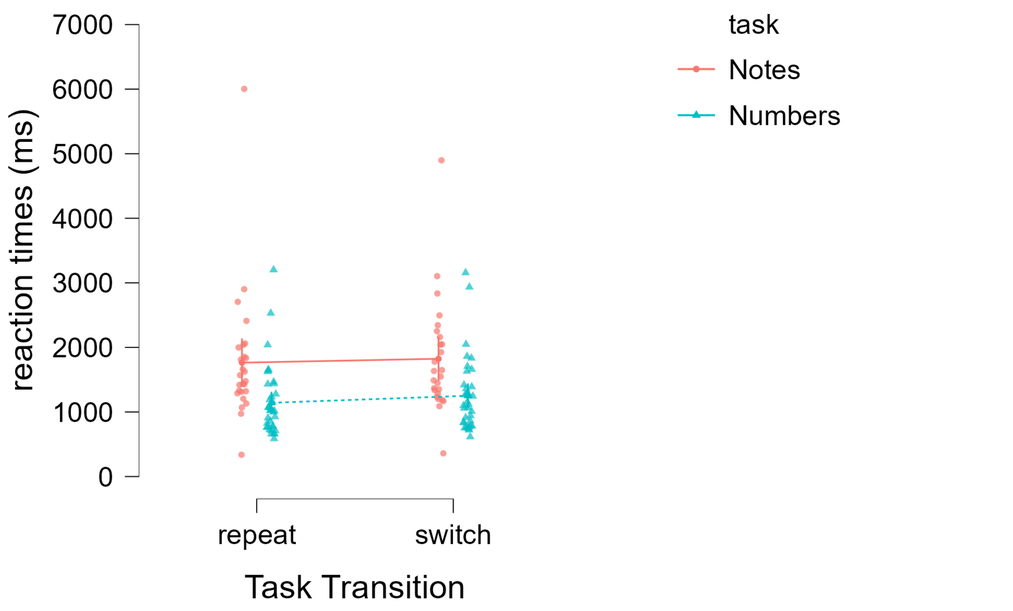

Fig. 2: Mean reaction times in ms in both experimental tasks of the music group. The difference between ”repeat” and “switch” trials results in switch costs. The non-musical task is solved faster than the musical task, but there is no difference in the switch costs of both tasks.

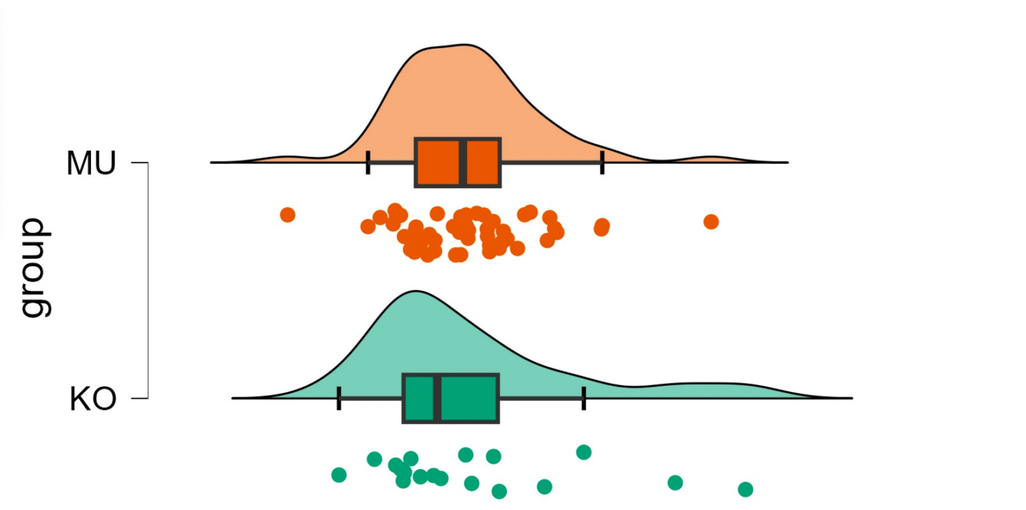

Fig. 3: Proportional switch costs (as ratio) for the music group (MU) and the control group (KO). Proportional switch costs were calculated in relation to repeat RT of each participant. There is no group difference in proportional switch costs.

Conclusion

- No difference in switch costs between the two tasks in the music group → no indication of a difference between near / far transfer (but note the difference in task difficulty).
- Higher music training resulted in smaller switch costs in the musical task → indication of near transfer, partial replication of Slama et al. (2017) who demonstrated an effect of music training on the same musical task.
- No group difference in the non-musical task → no indication for far transfer.

References: Gade, M., & Schlemmer, K. (2021). Music Modulates Cognitive Flexibility? An Investigation of the Benefits of Musical Training on Markers of Cognitive Flexibility. Brain Sciences, 11(4), Article 4. https://doi.org/10.3390/brainsci11040451 <> Müllensiefen, D., Gingras, B., Musil, J., & Stewart, L. (2014). The musicality of non-musicians: An index for assessing musical sophistication in the general population. PLOS ONE, 9, e89642. https://doi.org/10.1371/journal.pone.0089642 <> Slama, H., Rebillon, E., & Kolinsky, R. (2017). Expertise and cognitive flexibility: A musician’s tale. Journal of Cultural Cognitive Science, 1, 119–127. https://doi.org/10.1007/s41809-017-0011-5.