Mental Rotation in Visual and Musical Space

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INTRODUCTION

Statement:

Both visual and music patterns are organized within their respective systems of reference. We investigate a relation between success rate in visuo-spatial and music perception tasks

Amusic (tone-deaf individuals) show a significantly poorer performance on mental rotation task than musicians and non-musicians (Douglas & Bilkey, 2007).

Musicians have a different pattern of brain activation during mental rotation task as compared to non-musicians (Bhattacharya & Petsche, 2005).

Hypothesis:

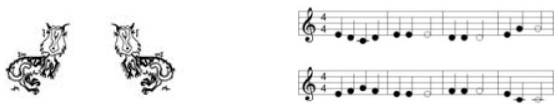
What if the brain process mental rotation and melodic transformation as a signal-distribution within a system of reference, notwithstanding the modality of the signal? What if navigation in the visual space and navigation in tonal space are alike and music experience improves spatial reasoning?

System of reference:

In music, differences in pitch and tonal attraction form tonal system of reference – a scale.

Visual and melodic images:

Visual images can be perceived at once, whereas melodic images unfold in time and when "mirrored" sound different. Yet a familiar melody can spring to memory as a whole, as if bypassing real time duration (Dalla Bella, Peretz, Aronoff, 2003).



METHOD

Participants:

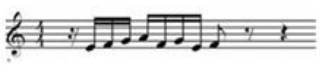
231 students of The University of Texas at Dallas, 163 females and 68 males. All 231 participants performed mental rotation and melodic transform task, while 114 of them (82 females and 32 males, performed additionally a control task on timbre change.

Material:

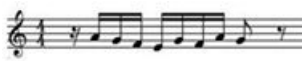
122 pairs of images of 3-D geometric objects (Meltzer & Shepard, 1971) and 27 melodies and their transforms. All melodies were from J. S. Bach works

Melodic congruency:

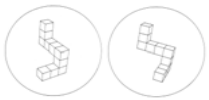
Tonal answer (**B**ent)



Inversion (**M**irrored).



Visual congruency:

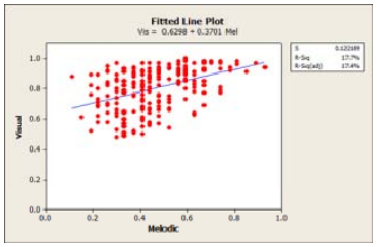


Melodic non-congruency: incomplete inversion (**C**omposite transform).

Control task: recognition of timbral change in the same 27 melodies from clavier compositions by J. S. Bach

RESULTS

1. **Correlation between the visuo-spatial and melodic tasks**: $r = .40$, $p < .001$



Linear regression on the data set of responses to the visuo-spatial and melodic transformation tasks

All	vis	mel	tim
exp	0.16	0.43***	0.18
vis		0.32***	0.26***
mel			0.22**

Females	vis	mel	tim
exp	0.12	0.48***	0.20
vis		0.28*	0.30**
mel			0.24*

Males	vis	mel	tim
exp	0.34	0.30	0.08
vis		0.46***	0.10
mel			0.20

*** $p < .001$
** $p < .01$
* $p < .05$

Correlation matrix for the visual, melodic, and timbre change tasks and musical experience for the subgroup of 114 participants

2. **Gender effect:** Males performed better on both mental rotation, t (229) = 4.92, $p < .01$, and melodic transformation, t (229) = 3.24, $p < .01$, tasks.

   The visual and timbral tasks correlated for females only, r = .30, $p < .05$.

   Musical experience and melodic transformation tasks correlated for females only, $r = .48$, $p < .001$

CONCLUSIONS

The results demonstrated a correlation between the mental rotation task and auditory task involving transformation of melodic contours. Males showed advantage in processing both the mental rotation and melodic transformation tasks. Moreover, the non-spatial control task on timbre change correlated with quasi-spatial melodic transformation task for females only. These results corroborate the previous investigations that show gender effect in mental rotation task, and suggest that processing visual and melodic mental rotation in men involves different cognitive mechanisms than in women.

Selection of mental rotation and melodic transformation tasks in this study was determined by an assumption that melodic objects, shaped by tonal forces, can be recognized as transcending their real-time duration and perceived as wholes. This assumption suggests that the way we process contour transformations is akin to the ways in which we process visual transformations. The implied involvement of a common mechanism in pattern-recognition within different systems of reference—visual and tonal—suggests that the higher mental functioning is less tied to the modality of perceptual patterns than is often assumed. However, this study was not equipped to answer the question of whether there is actual involvement of a shared neural substrate in processing mental rotations and melodic transformations.

Research in melodic contour transformation has important implications for our understanding of music's perceptual system of reference and the ways our mind generates representations of melodic objects within this system. Looking into the future, we hope that an investigation employing brain imaging techniques will someday deliver the crucial information on whether mental rotation and melodic transformation tasks have cross-modal mechanisms in common.