# Cognitive Abilities in Non-Musicians and Musicians: Does Musicality Matter?

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## Study Goals

- We conducted an individual differences investigation of the influence of musicality (measured with scores on the Gold-MSI) on working memory and fluid intelligence.

- Working memory and fluid intelligence were measured with commonly utilized complex span tasks (Operation and Symmetry), a novel Tonal complex span task, and Raven's (RAPM).

## Background

### Working Memory (WM)

- is defined as the to ability to maintain and manipulate task-relevant information while performing cognitive tasks.

- It is important to limit long-term strategies, chunking, and access to sensory memory when measuring capacity or span.

### Musical Working Memory

- Researchers debate if a domain specific musical system exists in all people, only trained musicians, or at all.

- Drastic methodological and criterial differences in measuring musical WM and musical ability across studies which creates difficulties in comparing results.

- Advantageous LTM strategies for musical WM can be developed through musical training and experiences.

### Complex WM Tasks

- are commonly used WM measures that require the storage of information while completing a secondary task.

- have consistent reliability and validity across domains, limit long term memory (LTM) abilities, and strongly predict fluid intelligence (Conway et. al., 2005).

- No musical complex span task exists, to our knowledge.

### Goldsmiths Musical Sophistication (MS) Index

(Müllensiefen et al., 2014)

- MS is a construct that refers to wide range of musical skills, expertise, achievements, and related behaviors.
- Measures MS through self-reports and perceptual tasks to compute a continuous scale of general MS and five subscales.
- Musical ability/training is measured by hours of regular daily practice, years of training, and other various aspects to provide a more representative measure instead of just formal years of training.
- Gold-MSI has shown internal consistency, test-retest reliability, and external validity with other music self-report and auditory tests.

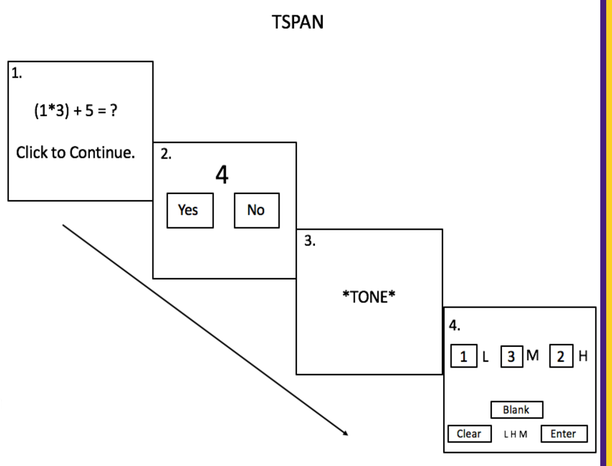
## Methodology

250 students from LSU completed the study. Criteria included: native English speaker, no hearing loss, and 85% accuracy on WM secondary tasks. **188 eligible participants met criteria**; Age *M* = 20.75 years, *SD* = 3.19, range 17-38. Completed 7 tasks in a 90 min block.

1. **Gold-MSI Self-Report:** 38-item inventory; create a composite score of general musical sophistication and five subscales of active musical engagement, perceptual abilities, musical ability, singing abilities, and emotion.

2. **Tonal Span (TSPAN):** Participants completed a two-step math operation and then tried to serially remember a tone (Figure 1). Tones were C4 (262 Hz), G4 (392 Hz), and B4 (494 Hz) and were labeled low, middle, and high respectively.

**Figure 1**




3. **Symmetry Span (SSPAN):** Participants completed a two-step symmetry judgment and then tried to serially remember locations of red squares.

4. **Operation Span (OSPAN)**: Participants completed a two-step math operation and then tried to serially remember a letter in an alternating sequence.

5. **Gold-MSI Beat Perception Test:** 18 excerpts of instrumental music from rock, jazz, and classical genres were played. Judgments indicated if a metronomic beep was on beat.

6. **Gold-MSI Melodic Memory Test:** Participants were presented melodies between 10 to 17 notes. During each trial, two versions of a melody were presented. A same or different judgment was made after second version.

7. **Raven's Advanced Progressive Matrices (RAPM):** Participants were presented a 3 x 3 matrix of geometric patterns with one pattern missing and had to choose one of 8 patterns that fit the matrix. Measures fluid intelligence.

## Results

**Table 1** Descriptive statistics (N=188)

| Measures | M | SD | Range | Skew | Kurtosis | Reliability |
|---|---|---|---|---|---|---|
| Raven | 24.78 | 4.61 | 14-36 | -.05 | -.59 | .81 |
| OSPAN | 57.77 | 14.7 | 12-75 | -1.27 | 1.12 | .88 |
| SSPAN | 30.11 | 7.24 | 8-42 | -.73 | .31 | .75 |
| TSPAN | 53.85 | 12.41 | 18-75 | -.61 | -.34 | .82 |
| BeatAc | .68 | .14 | .33-.89 | -.11 | -.71 | - |
| MelodicAc | .64 | .16 | .23-1.00 | -.13 | .00 | - |
| General | 83.91 | 21.69 | 24-122 | -.33 | -.80 | .93* |
| Musical | 28.04 | 12.53 | 7-47 | -.26 | -1.24 | .90* |
| Active | 42.50 | 9.94 | 13-62 | -.38 | -.44 | .87* |
| Perceptual | 50.03 | 8.00 | 30-63 | -.42 | -.70 | .87* |
| Singing | 32.21 | 8.23 | 8-49 | -.15 | -.51 | .87* |
| Emotion | 35.10 | 4.71 | 14-42 | -1.05 | 1.85 | .79* |
| FormalYrs | 5.0 | 4.70 | 0-21 | .81 | .01 | - |

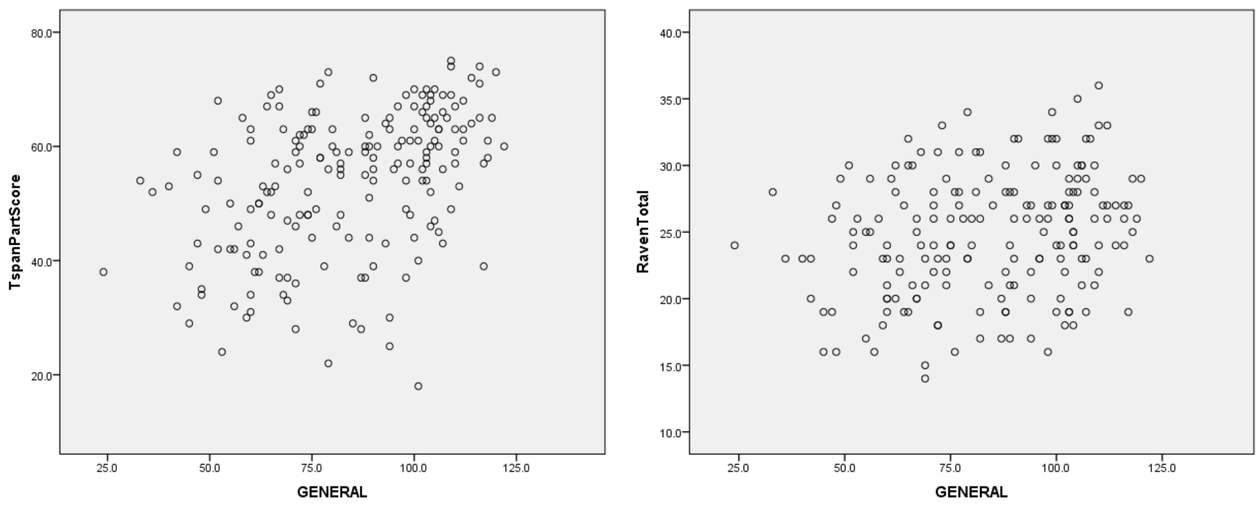
Note: RAPM= Ravens ; OSPAN = Operation span; SSPAN = Symmetry span; TSPAN = Tonal span; BeatAc = Beat perception accuracy; MelodicAc = Melodic memory accuracy; General = General musical sophistication; Musical = Musical ability; Active = Active musical engagement; Perceptual = Perceptual ability; Singing = Singing ability; Emotion = Emotional engagement with music; FormalYrs = Years of formal music training.
Reliability measured with Cronbach's alpha. * From Müllensiefen et al., 2014.

**Table 2** Correlations among the gF, WM, Objective and Subjective Measures of Musicality.

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| gF | | | | | | | | | | | | |
| 1.RAPM | - | | | | | | | | | | | |
| WM | | | | | | | | | | | | |
| 2 OSPAN | .30** | - | | | | | | | | | | |
| 3.SSPAN | .37** | .60** | - | | | | | | | | | |
| 4. TSPAN | .40** | .55** | .58** | - | | | | | | | | |
| GMSI-P | | | | | | | | | | | | |
| 5 .BeatAc | .30** | .13 | .16* | .27** | - | | | | | | | |
| 6.MelodicAc | .23** | .18* | .22* | .33** | .17* | - | | | | | | |
| GMSI-SR | | | | | | | | | | | | |
| 7. General | .24** | .10 | .17* | .42** | .41** | .28** | - | | | | | |
| 8. Musical | .29** | .11 | .17* | .47** | .42** | .30** | .87** | - | | | | |
| 9. Active | .15* | .10 | .08 | .27** | .24** | .17* | .74** | .57** | - | | | |
| 10. Percep | .22** | .05 | .11 | .26** | .32** | .25** | .81** | .66** | .57** | - | | |
| 11. Singing | .13 | .11 | .14 | .32** | .29** | .21** | .86** | .63** | .52** | .71** | - | |
| 12. Emotion | .16* | -.02 | .01 | .19** | .29** | .18* | .71** | .54** | .77** | .64** | .51** | - |

Note: *gF* = General fluid intelligence; RAPM= Ravens ;WM = Working memory; OSPAN = Operation span; SSPAN = Symmetry span; TSPAN = Tonal span; GMSI-P = Goldsmith musical sophistication index – perceptual; BeatAc = Beat perception accuracy; MelodicAc = Melodic memory accuracy; GMSI-SR = Goldsmith musical sophistication index – self report; General = General musical sophistication; Musical = Musical ability; Active = Active musical engagement; Percep = Perceptual ability; Singing = Singing ability; Emotion = Emotional engagement with music.** significant at the .001 level (2-tailed) and * significant at the .05 level (2-tailed)

**Figure 2**
Scatterplots of TSPAN and Gold-MSI General Musical Ability Composite Score, and RAPM and General Composite.




## Regression Analyses

Predicted Tspan Score from the General Composite Score- **$R^2$ = .17.**
*F* (1, 187) = 39.47, *p* < .001.

Predicted Sspan Score from the General Composite Score- **$R^2$ = .03.**
*F* (1, 187) = 5.59, *p* = .02.

The analysis with Ospan was not significant.

Predicted RAPM from the General Composite Score- **$R^2$ = .05.**
*F* (1, 187) = 10.88, *p* = .001.

## Discussion

Complex span tasks were positively and significantly correlated to one another, and were similarly correlated with fluid intelligence.

On a surface level, these results indicate that Tonal span is a valid complex span measure of musical WM and support a domain-general WM construct (e.g., Kane et al., 2004).

Melodic memory performance was significantly related with WM tasks, possibly supporting research suggesting executive functions can predict pitch memory and discrimination (e.g., Hou et al., 2014). Future work needs to disentangle the commonalities of the memory requirements in these tasks.

The regression analyses indicated that the strongest predictor of the Gold-MSI General Composite Score was the Tspan task, but both Sspan and RAPM were significant as well. Ospan did not correlate with the self-report scores or the General score, and was not significant in the regression analysis.

## Future Directions

Create a Tonal span with a secondary musical processing task to better limit LTM strategies.

Include developmental assessment of musical WM, particularly in musically-trained children, to measure music training's effect on WM and musical WM capacity's growth throughout childhood in comparison to other domains. May provide insight on underlying cause of general WM development.

## References

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