Investigating the Relationship between Musical Working Memory and Musical Sophistication in Non-Musicians

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Study Goals

- Individual differences investigation of the influence of non-musicians' musicality (measured with scores on the Gold-MSI) on working memory and fluid intelligence.

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

Background

Working Memory (WM)

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

- 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

- 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.

Goldsmith's 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 in non-musicians 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

120 students from LSU completed the study. Criteria included: native English speaker, no hearing loss, no music-related area of study, 85% accuracy on WM secondary tasks, < 9 years of formal music training, and no absolute pitch . **84 eligible participants met criteria**; Age M = 20.05 years, SD = 2.09, range 17-31. Completed 7 tasks in a 90 min block.

1. **Gold-MSI Self-Report:** 70-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. Non-musicians struggle to discriminate more than 3 tones in recall tasks (see Williamson, Baddeley, & Hitch, 2010). Tone selection limits use of musical structures (e.g. intervals and harmonics).

3. **Symmetry Span (SSPAN):** Participants completed a two-step symmetry judgement 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. Judgements were made on 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. The second version was transposed to a different key. In half of the second version melodies, the pitch interval structures were altered by changing the melodic contour or the intervallic structure. 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.

Figure 1
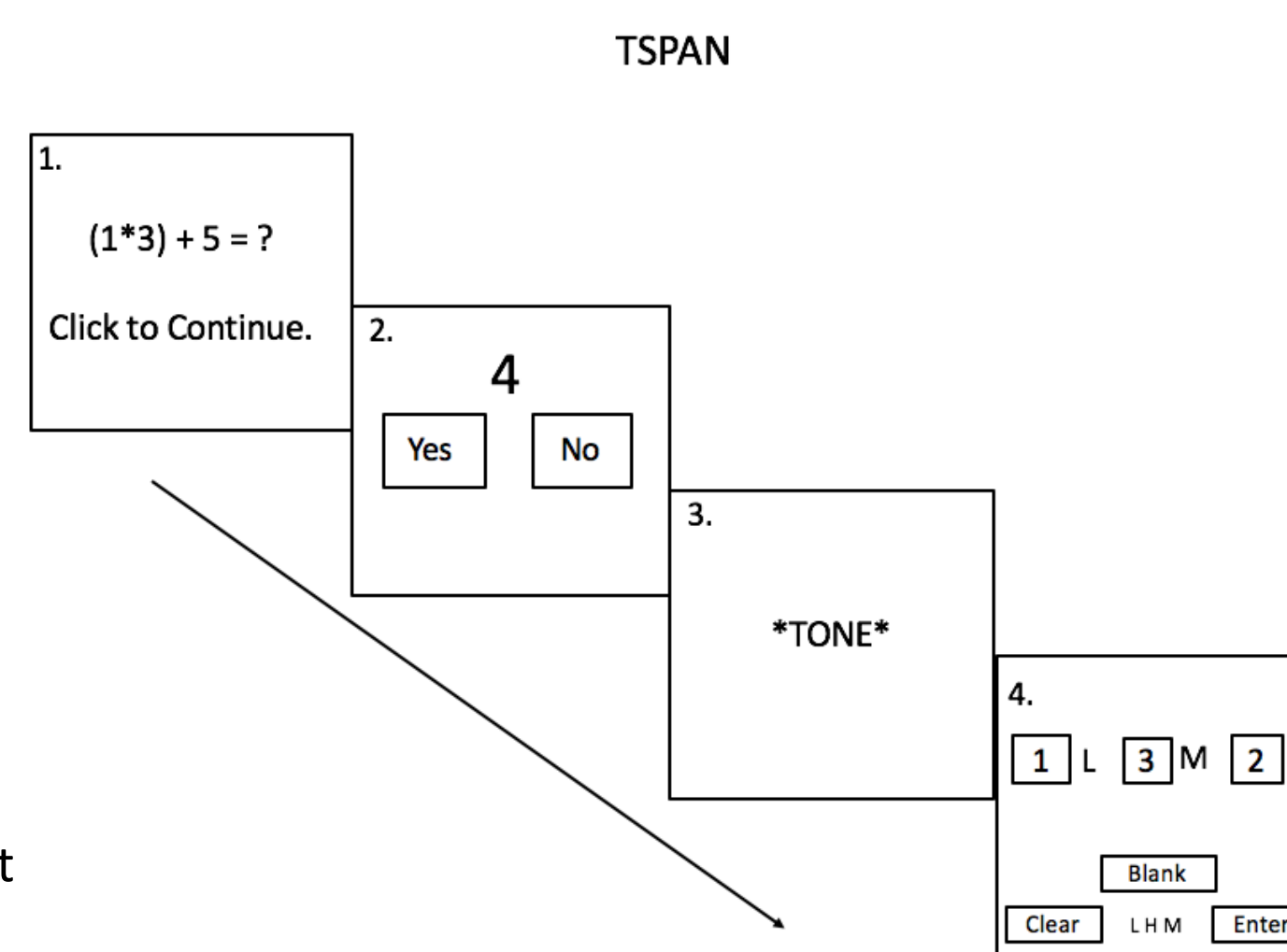
Results

Table 1
Descriptive statistics (N=84)

Measures	M	SD	Range	Skew	Kurtosis	Reliability
Raven	23.63	4.84	12-34	-.10	-.54	.82
OSPAN	55.36	15.96	8-73	-1.25	.95	.89
SSPAN	29.06	7.69	5-42	-.68	.54	.78
TSPAN	48.46	13.83	12-74	-.26	-.58	.86
BeatAc	.64	.12	.39-.89	-.13	-.43	-
MelodicAc	.62	.15	.23-.92	-.28	-.21	-
General	71.94	18.92	24-116	.04	-.31	.93*
Musical	20.39	10.44	7-45	.46	-.80	.90*
Active	38.93	9.12	18-62	-.003	-.02	.87*
Perceptual	46.51	7.74	30-61	.026	-.69	.87*
Singing	28.41	7.44	8-42	-.13	-.21	.87*
Emotion	33.38	4.42	18-42	-.62	.50	.79*
FormalYrs	2.19	2.41	0-8	.92	-.27	-
TheoryYrs	0.98	1.82	0-8	1.97	3.22	-

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; TheoryYrs = Years of music theory training. Reliability measured with Cronbach's alpha. * From Müllensiefen et al., 2014.

Table 2
Correlations among variables.

Variable	1	2	3	4	5	6	7	8	9	10	11	12
gF												
1.RAPM	-											
WM												
2 OSPAN	.23*	-										
3.SSPAN	.38**	.70**	-									
4. TSPAN	.44**	.62**	.70**	-								
GMSI-P												
5 .BeatAc	.29**	.07	.23*	.19	-							
6.MelodicAc	.22*	.29**	.28**	.35**	.04	-						
GMSI-SR												
7. General	.04	-.07	-.001	.16	.28**	.16	-					
8. Musical	.07	-.07	-.01	.21	.25*	.14	.81**	-				
9. Active	.01	.04	-.01	.12	.11	.03	.63**	.34**	-			
10. Percep	-.01	-.04	-.05	.05	.16	.08	.76**	.55**	.47**	-		
11. Singing	-.04	-.01	.08	.09	.18	.15	.84**	.55**	.44**	.66**	-	
12. Emotion	-.01	-.10	-.14	.01	.16	.04	.58**	.28**	.71**	.52**	.41**	-

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
** Correlation is significant at the .001 level (2-tailed) and * Correlation is significant at the .05 level (2-tailed)

Figure 2
Scatterplot of correlational relationship between TSPAN and Gold-MSI Musical Ability Composite Score.
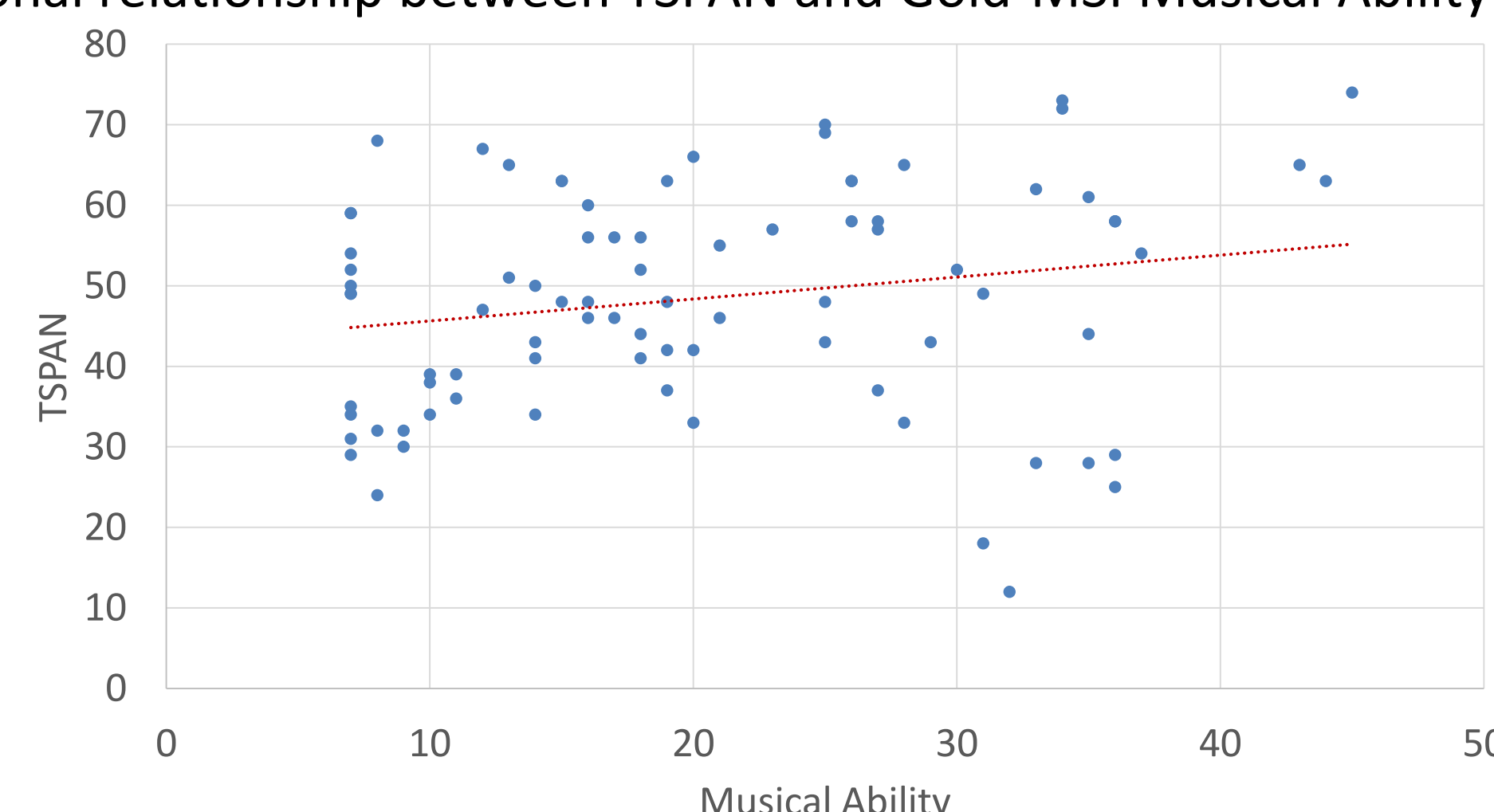
Discussion

- Complex span tasks were positively and significantly correlated to one another (construct validity), reliable, 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).

- We found an inconclusive relationship with WM and self-report Gold-MSI scores. We did not include expert or advanced musicians. Thus, this supports theories that suggest a domain-specific musical system does not exist in non-musicians and potentially only in expert musicians (e.g., Schulze et al., 2011).

- Melodic memory performance strongly related with WM tasks, supporting research suggesting executive functions can predict pitch memory and discrimination (e.g., Hou et al., 2014).

- Beat perception may only underlie visuospatial and timing characteristics related to musical reading and performance.

- RAPM was unrelated to self-report Gold-MSI scores, thus suggesting inconclusive evidence in support of musical experience enhancing fluid intelligence in non-musicians.

Future Directions

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

- Compare musicians vs non-musicians on tasks to access domain generality of WM and fluid intelligence enhancement.

- 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.

- Assess differences in musical WM measures (complex span, visual array, recognition, etc.).

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