Psychomusicology: Music, Mind, and Brain

A First Look at the Role of Domain-General Cognitive and Creative Abilities in Jazz Improvisation

Roger E. Beaty, Bridget A. Smeekens, Paul J. Silvia, Donald A. Hodges, and Michael J. Kane
Online First Publication, November 18, 2013. doi: 10.1037/a0034968

Psychomusicology: Music, Mind, and Brain

0275-3987/13/$12.00 DOI: 10.1037/a0034968

A First Look at the Role of Domain-General Cognitive and Creative Abilities in Jazz Improvisation

Roger E. Beaty, Bridget A. Smeekens, Paul J. Silvia, Donald A. Hodges, and Michael J. Kane
University of North Carolina at Greensboro

The present study explored the associations among several cognitive and creative abilities and expert ratings of jazz improvisational quality. Ten male undergraduate jazz students (8 performance majors, 2 education majors; 5 winds, 3 strings, 1 piano, and 1 drum) performed a video-recorded improvisation with a trio and completed measures of divergent thinking, working memory, and fluid intelligence. Performances were rated for creative quality by 3 expert raters. Students also answered questions regarding their musical background and subjective experience of improvisation. As expected, cumulative practice hours substantially predicted improvisational creativity. Results for the cognitive variables showed mostly negative correlations with improvisation; however, divergent thinking strongly predicted performance quality. We consider these results in the context of the literature on expertise and creativity.

Keywords: improvisation, intelligence, divergent thinking, expertise, working memory capacity

Supplemental materials: http://dx.doi.org/10.1037/a0034968.supp

Conventional wisdom holds that "practice makes perfect," a notion supported by decades of empirical research with eminent musicians (Ericsson, Krampe, & Tesch-Römer, 1993; Howe, Davidson, & Sloboda, 1998). *Deliberate* practice, "a very specific activity designed for an individual by a skilled teacher explicitly to improve performance" (Krampe & Ericsson, 1996, p. 333), is widely accepted as necessary to achieve mastery in a domain. But some researchers are beginning to question whether practice alone is sufficient (Hambrick et al., in press; Meinz & Hambrick, 2010). An emerging literature suggests that domain-general abilities, such as fluid reasoning and working memory capacity (WMC), supplement domain-specific abilities to enhance musical performance quality.

Meinz and Hambrick (2010), for example, explored the contribution of WMC to sight-reading performance in a sample of classically trained pianists. Participants sight-read six unfamiliar songs—later judged by two expert raters—and completed measures of WMC and a questionnaire regarding their musical background. Cumulative lifetime practice hours explained half of the sight-reading variance. WMC accounted for an additional 8% of variance beyond practice, however, suggesting that practice is necessary but not sufficient to achieve musical expertise.

Roger E. Beaty is a graduate student in psychology at the University of North Carolina at Greensboro. His research focuses on the study of creativity, and the cognitive processes that underlie the generation of new ideas. He uses behavioral and neuroimaging methods to investigate creative behavior in the arts and everyday life.

Roger E. Beaty, Bridget A. Smeekens, Paul J. Silvia, and Michael J. Kane, Department of Psychology, University of North Carolina at Greensboro; Donald A. Hodges, School of Music, Theatre and Dance, University of North Carolina at Greensboro.

Correspondence concerning this article should be addressed to Roger E. Beaty, Department of Psychology, University of North Carolina at Greensboro, P.O. Box 26170, Greensboro, NC 27402-6170. E-mail: rebeaty@uncg.edu

Regarding the creative quality of instrumental improvisation, De Dreu, Nijstad, Baas, Wolsink, and Roskes (2012) recorded three improvisations and assessed subjects' WMC. Two professional cellists rated the performances for overall creativity. The researchers expected the creative quality of high WMC participants to be sustained or increased across trials, presuming that these individuals could maintain focused attention and inhibit the proactive interference from earlier improvisations. As expected, WMC predicted the creative quality of improvisations across time. Domain-general cognitive abilities thus seem important to both musical improvisation and sight-reading performance.

But why might domain-general cognitive abilities improve improvisation? According to Pressing's (1988) framework—perhaps the most influential model of jazz improvisation—improvisation involves the continuous generation and evaluation of melodic ideas in real time. Such a demanding task should recruit general cognitive resources to manage the many simultaneous processes required. Other models of improvisation have attempted to integrate the apparent interplay between divergent and convergent modes of improvisational thought (Webster, 1990). Although these models imply a role of general abilities in improvisation, few empirical studies have examined the contribution of such abilities in jazz performance. In the present research, we thus explored the associations among jazz improvisation quality, deliberate practice, and general cognitive and creative abilities.

Method

Participants

Ten male jazz students from the University of North Carolina at Greensboro volunteered to participate in the study (eight performance majors, two education majors; saxophone = three, guitar = two, trumpet = one, trombone = one, bass = one, piano = one, drums = one). Students varied in their year of academic progress. A trio of jazz performance majors (piano, bass, and drums) was

Table 1
Correlations and Descriptive Statistics

Variable	*M*	*SD*	Minimum, maximum	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Practice (week)	14.20	8.70	5, 30	1																							
2. Improv: Rater 1	4.20	1.81	1, 7	.73	1																						
3. Improv: Rater 2	4.10	1.59	1, 7	.55	.79	1																					
4. Improv: Rater 3	3.40	1.17	2, 6	.63	.79	.86	1																				
5. Improv: Avg.	0.00	.93	−1.63, 1.86	.68	.92	.94	94	1																			
6. DT: Rater 1	2.00	.66	1, 3	.36	.36	.20	.42	.35	1																		
7. DT: Rater 2	1.90	.99	1, 4	.47	.62	.63	.70	.70	.83	1																	
8. DT: Rater 3	1.80	.78	1, 3	.52	.57	.63	.57	.63	.63	.82	1																
9. DT: Avg.	0.00	.91	−1.14, 1.71	.49	.57	.53	.62	.61	.89	.96	.89	1															
10. WMC: SSPAN	34.00	5.97	26, 42	−.15	−.11	−.47	−.52	−.39	.00	−.23	−.40	−.23	1														
11. WMC: OSPAN	67.36	5.52	59, 75	−.14	−.51	−.75	−.70	−.70	.12	−.27	−.06	−.07	.28	1													
12. WMC: Avg.	0.00	.80	−1.43, .73	−.18	−.39	−.77	−.76	−.68	.07	−.31	−.29	−.19	.80	.80	1												
13. Gf: Letters	11.44	1.87	10, 15	−.21	−.36	−.31	−.52	−.42	−.23	−.31	−.32	−.31	.67	.11	.49	1											
14. Gf: Numbers	9.88	2.02	7, 13	.01	.00	−.29	−.07	−.13	.35	.17	.35	.32	.11	.48	.37	−.21	1										
15. Gf: CFIQ	7.66	1.50	6, 10	−.25	−.54	−.83	−.71	−.74	−.07	−.55	−.56	−.43	.68	.67	.84	.41	.23	1									
16. Gf: Avg.	0.00	.65	−.92, .89	−.22	−.43	−.73	−.66	−.66	.02	−.35	−.27	−.21	.75	.64	.87	.61	.51	.83	1								
17. ITQ: Control	5.00	1.05	3, 6	.31	.75	.79	.62	.78	.15	.53	.66	.49	−.22	−.56	−.49	−.21	.15	−.69	−.38	1							
18. ITQ: Conscious	4.20	1.61	2, 6	−.29	−.58	−.56	−.63	−.63	.00	−.40	−.13	−.19	.24	.68	.58	.33	.14	.69	.59	−.45	1						
19. ITQ: Decide	3.10	1.44	1, 6	.21	.00	−.34	−.41	−.27	.00	−.22	−.27	−.18	.78	.35	.71	.71	−.11	.56	.59	−.29	.27	1					
20. ITQ: Plan	3.50	1.71	2, 7	.26	−.07	−.18	−.33	−.15	−.48	−.55	−.24	−.46	.45	.23	.43	.34	.07	.47	.45	.00	.32	.55	1				
21. ITQ: Emotion	5.00	1.49	3, 7	.00	−.08	.04	.00	−.01	.11	.22	.09	.15	−.02	.04	.00	−.23	.00	.03	−.10	−.14	−.04	−.30	−.17	1			
22. ITQ: Previous	3.90	1.44	2, 6	.38	.68	.67	.67	.72	.00	.37	.36	.27	−.58	−.53	−.69	−.63	−.12	−.83	−.80	.58	−.79	−.41	−.24	−.15	1		
23. ITQ: Group	5.20	.78	4, 7	.43	.43	.42	.50	.48	.21	.45	.07	.26	.10	−.51	−.25	−.07	−.20	−.23	−.25	.13	−.64	−.01	−.16	.56	.21	1	
24. ITQ: Rehearse	3.90	1.85	1, 6	.21	.53	.71	.48	.61	−.09	.23	.13	.10	.03	−.77	−.46	.07	−.51	−.38	−.41	.56	.28	−.07	.12	.20	.20	.47	1

Note. $n = 10$. ITQ items are listed in the order they appear in the Appendix. WMC = working memory capacity; SSPAN = symmetry span; OSPAN = operation span; DT = divergent thinking; Gf = fluid intelligence; ITQ = Improvisational Thinking Questionnaire.

paid to assist with the study by serving as a backing band. We provided a catered lunch to compensate students for their participation.

Procedure

The study took place in a large ensemble room in the music department of the University of North Carolina at Greensboro. After performing an improvisation, students were asked to complete several cognitive tasks and a questionnaire. All measures were administered electronically using E-Prime.

Improvisation. Performances were recorded with a digital video camera. Students were presented with the instrumental lead sheet from *I Hear a Rhapsody* by George Fragos, Jack Baker, and Dick Gasparre. All students claimed to have never previously performed this piece. After a practice trial (1 min), they played the melody with the trio once and then improvised over two complete iterations of the song (2 min). Performance videos were later scored using the consensual assessment technique (Amabile, 1982) by three associate professors of jazz studies at separate institutions. Each performance video was scored on a 7-point scale for creativity (i.e., a holistic score of the improvisation quality; Appendix A). Videos were uploaded to a Web site dedicated to the study along with a link to a Qualtrics survey used for scoring.

Divergent thinking task. After the recorded performance, students completed a 3-min divergent thinking task—a classic measure of verbal creativity that predicts real-world creative achievement (Plucker, 1999; Torrance, 1988). The aim of this task is to generate unusual and uncommon uses for an everyday object (i.e., a brick). Students received instructions to "be creative" and "to come up with something clever, humorous, original, compelling, or interesting." Three research assistants, all unaware of the jazz performance and cognitive ability scores of the subjects, scored each response independently on a 1 (*not at all creative*) to 5 (*very creative*) scale, using combined criteria of novelty, remoteness, and cleverness (Silvia et al., 2008).

Cognitive tasks. Students were then given three fluid intelligence (Gf) tests that assessed inductive reasoning: (1) a letter sets task (Ekstrom, French, Harman, & Dermen, 1976), (2) the matrices task from the Cattell Culture Fair Intelligence Test (Cattell & Cattell, 1961/2008), and (3) a number series task (Thurstone, 1938). These tasks appear in our past research on intelligence and creativity (Beaty & Silvia, 2012, 2013; Silvia & Beaty, 2012). Students also completed two WMC measures: operation span (OSPAN; Unsworth, Heitz, Shrock, & Engle, 2005) and symmetry span (SSPAN; Kane et al., 2004). Both tasks measure participants' ability to hold to-be-recalled information in memory (OSPAN: 3–7 letters; SSPAN: 2–5 locations in a matrix) while answering a series of questions (OSPAN: verifying equations; SSPAN: verifying symmetry of patterns).

Questionnaires. We administered two questionnaires to assess musical history and beliefs about improvisation. The musical history questionnaire included items borrowed from Ericsson et al. (1993) to assess deliberate practice and musical background. An Improvisational Thinking Questionnaire was developed by us to

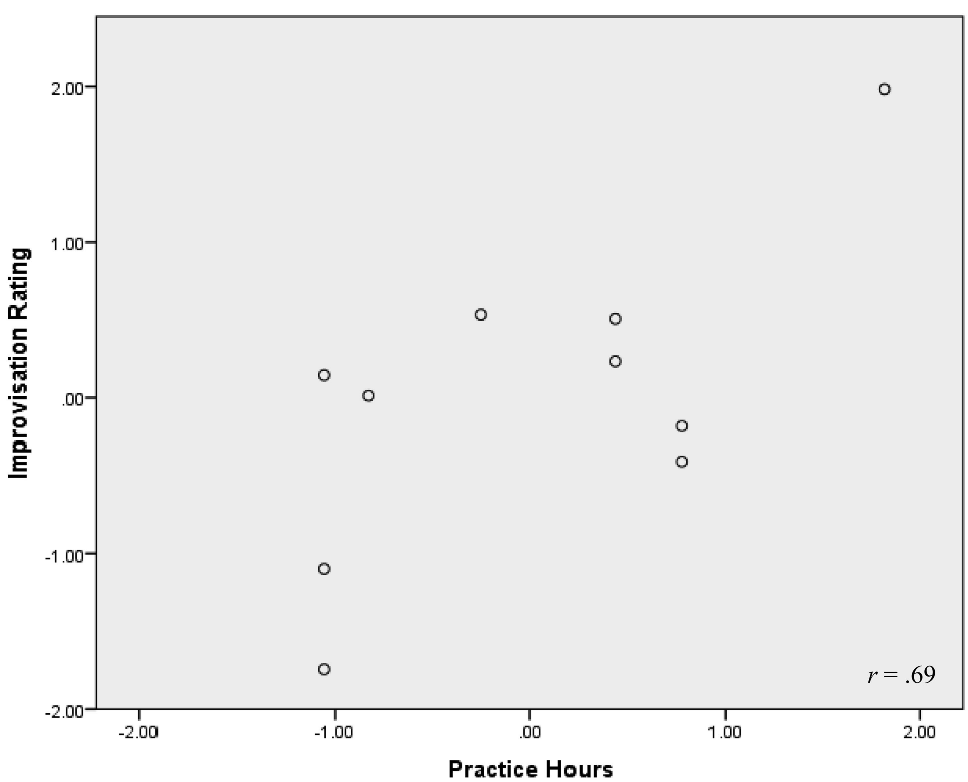

Figure 1. Relationship between the standardized composite improvisation ratings and standardized annual practice hours.

evaluate student beliefs about improvisation (Appendix B; e.g., "To what extent do you feel that you are in control of the direction of your playing?"). Students responded to each item on a 7-point scale (1 = *not at all*, 7 = *very much*).

Results

Table 1 displays correlations and descriptive statistics. Ratings of improvisational quality and divergent thinking were each averaged to form separate composite variables for analysis. Likewise, we averaged the scores among the Gf and WMC tasks. Due to time constraints, one student was unable to complete the WMC tasks, and another student was unable to complete both the WMC and Gf tasks. Interrater reliability was high for both improvisation ($\alpha = .91$) and divergent thinking ($\alpha = .94$). Self-reported weekly deliberate-practice hours were multiplied by 52 to estimate a total number of practice hours per year (Meinz & Hambrick, 2010). Because of the small sample size, we report effect sizes rather than p values and inferential tests (Kline, 2004). Using the r metric, effect sizes of .10, .30, and .50 are considered benchmarks for small, medium, and large effects (Cohen, 1988), respectively.

Improvisation and Cognitive Abilities

To what extent were expertise and cognitive abilities associated with improvisation quality? As expected, deliberate practice was strongly correlated with the composite performance scores ($r = .69$; Figure 1). Correlations of improvisation quality with WMC and Gf, the cognitive measures, were negative. We thus estimated a regression model with practice hours and Gf predicting improvisation quality. This model showed a large main effect of practice ($\beta = .56$) and negative effect of Gf ($\beta = -.53$, $R^2 = .73$; Figure 2). A similar model was estimated for practice and WMC: practice's effect was positive ($\beta = .55$) and working memory's effect was negative ($\beta = -.59$, $R^2 = .79$; Figure 3). In sum, these analyses suggest a negative relation between general cognitive abilities and improvisation scores.

Improvisation and Divergent Thinking

We then considered the role of general creative abilities in performance quality. The correlation between improvisation and the composite divergent thinking average was large ($r = .63$; Table 1). We thus estimated a regression model predicting improvisation quality with divergent thinking and practice hours. A moderate positive effect was found for divergent thinking ($\beta = .36$), and a large effect was found for practice hours ($\beta = .50$; Figure 4). This model explained more than half of the variance in improvisation scores ($R^2 = .57$).

Improvisational Thinking Questionnaire

Performance on the cognitive measures was substantially associated with items describing controlled aspects of the Im-

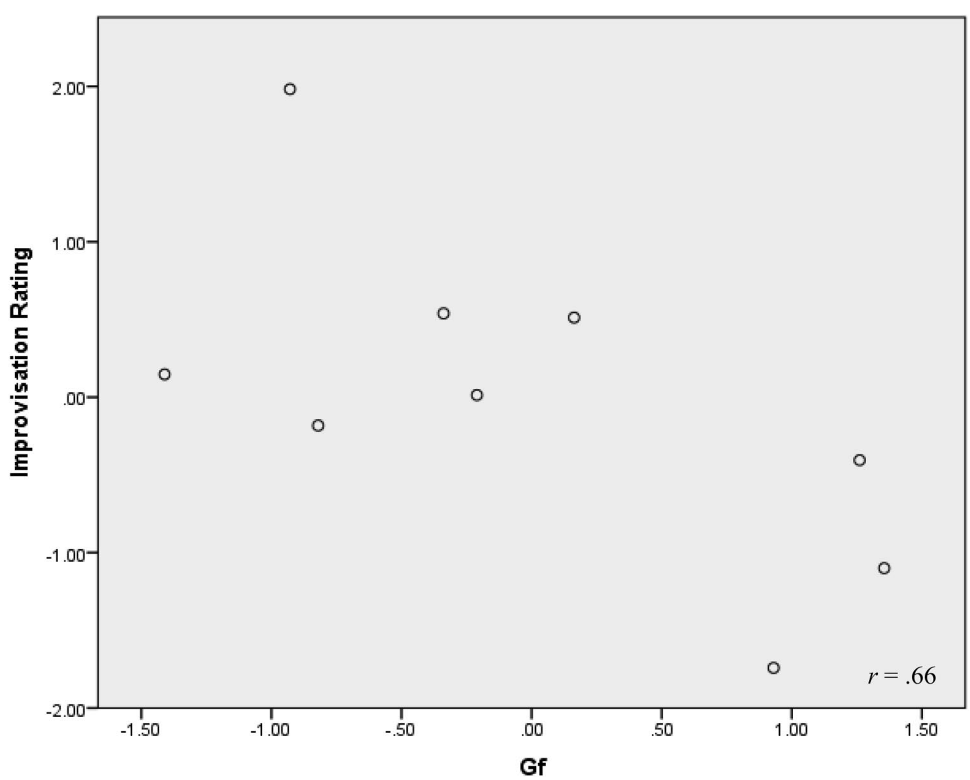

Figure 2. Relationship between standardized composite improvisation ratings and standardized composite Gf scores.

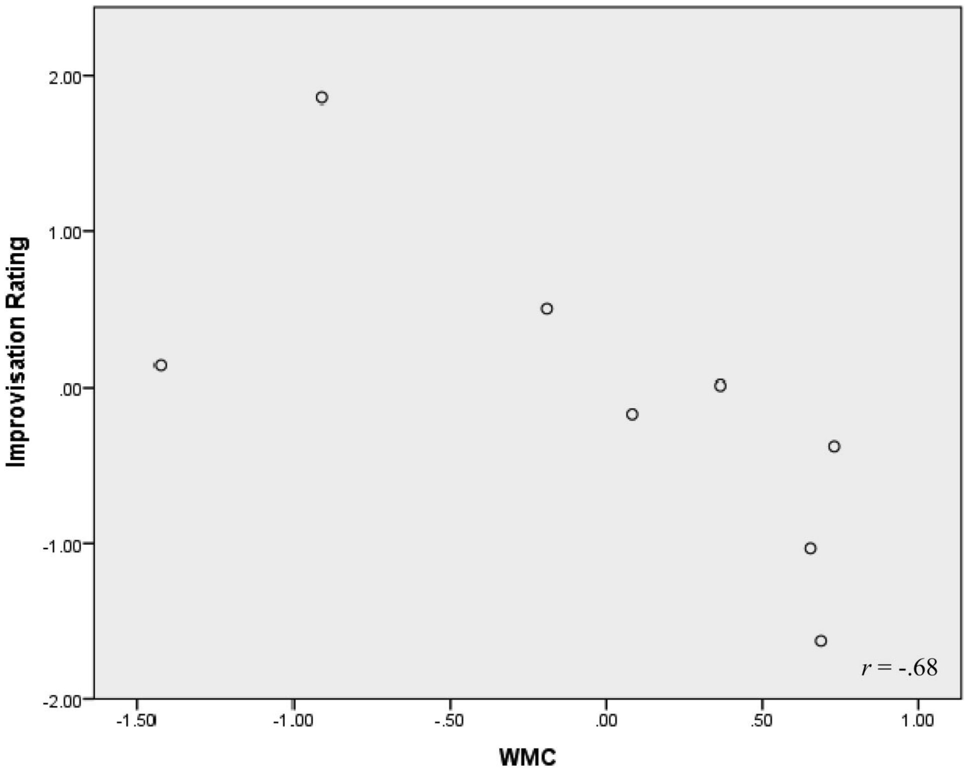

Figure 3. Relationship between standardized composite improvisation ratings and standardized composite WMC scores.

provisational Thinking Questionnaire (Appendix B): WMC predicted self-reported conscious direction of improvisation (i.e., item 2; $r = .66$), as well as musical decision making (i.e., item 3; $r = .72$). The degree to which students reported incorporating previously improvised melodic material in their playing was positively related to improvisation performance scores (i.e., item 6; $r = .72$) and negatively related to variables associated with cognitive ability (WMC, $r = -.81$; Gf, $r = -.77$) and conscious direction of improvisation ($r = -.79$). Overall, self-reported experiences of improvisation appeared to covary with both general cognitive abilities and expert ratings of performance.

Discussion

In the present study, we examined the role of general abilities to explore whether acquired expertise is sufficient for jazz improvisation quality. Verbal creativity—assessed via divergent thinking—was highly correlated with improvisational creativity ($r = .63$), and it predicted experts' performance ratings in a regression model controlling for practice hours ($\beta = .36$). We also found that Gf and WMC were *negatively* associated with expert ratings of improvisation quality. Although these results were surprising and inconsistent with previous findings (De Dreu et al., 2012), there is reason to believe they were influenced by a few important characteristics of the data; for example, the variance in performance on the cognitive measures was exceedingly restricted.

Furthermore, we conducted a follow-up analysis with the divergent thinking and cognitive ability data. Using large data sets from our institution's undergraduates who participated in previous studies of creativity and cognitive ability, we compared the musicians' performance with the norm sample on all measures of interest (i.e., divergent thinking, Gf, and WMC). Musicians were a full standard deviation higher on all of the cognitive measures, replicating previous research showing an advantage of musicians compared with nonmusicians on measures of cognitive ability (Bidelman, Hutka, & Moreno, 2013; Hansen, Wallentin, & Vuust, in press). This was not the case for divergent thinking, however: musicians performed less than a quarter of a standard deviation better than our normed sample. We are thus less certain about the findings for Gf and WMC and leave it to future research to further explore this issue.

Limitations and Future Directions

The present research offers preliminary data on the understudied field of musical improvisation. Due to the small sample, our analyses focused on effect sizes, and less on conventional significance tests. We also focused on musicians' ability to sight-improvise—using lead sheets to improvise with unfamiliar chord changes. Future work should assess musicians' ability to improvise within more familiar contexts, and further examine how general abilities influence improvisational quality with a larger and more diverse sample. Although deliberate practice is certainly necessary to achieve musical expertise, this study and

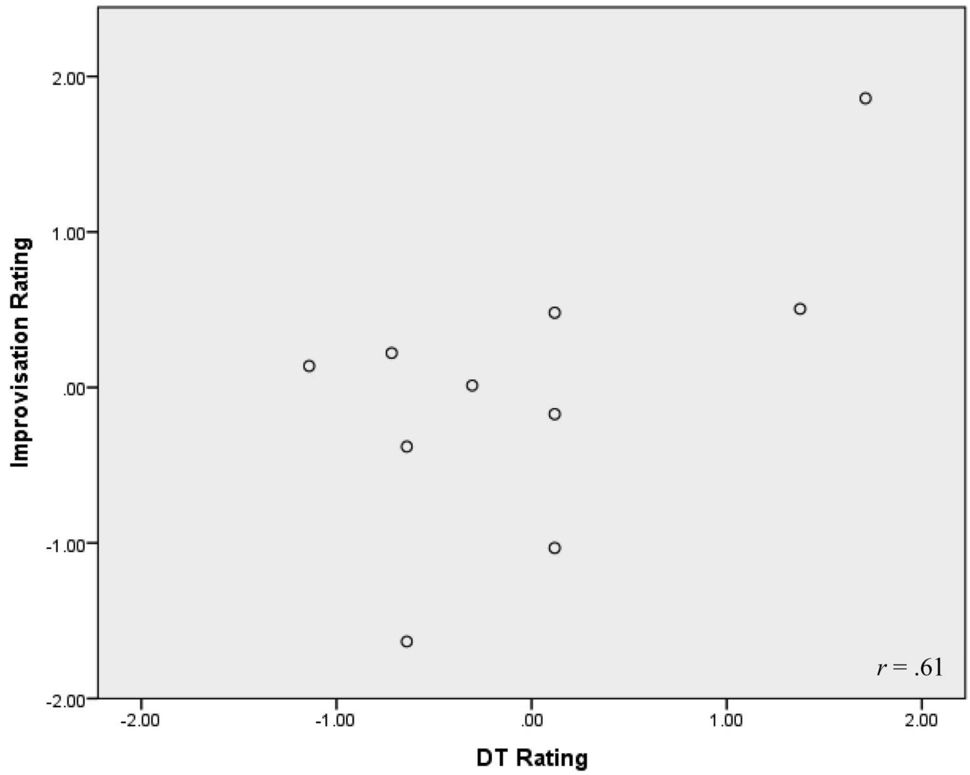

Figure 4. Relationship between standardized composite improvisation ratings and standardized composite divergent thinking scores.

others suggest that researchers should take a new look at the longstanding notion that practice alone is sufficient.

References

Amabile, T. M. (1982). Social psychology of creativity: A consensual assessment technique. *Journal of Personality and Social Psychology, 43,* 997–1013. doi:10.1037/0022–3514.43.5.997

Beaty, R. E., & Silvia, P. J. (2012). Why do ideas get more creative across time? An executive interpretation of the serial order effect in divergent thinking tasks. *Psychology of Aesthetics, Creativity, and the Arts, 6,* 309–319. doi:10.1037/a0029171

Beaty, R. E., & Silvia, P. J. (2013). Metaphorically speaking: Cognitive abilities and the production of figurative language. *Memory and Cognition, 41,* 255–267. doi:10.3758/s13421-012-0258-5

Bidelman, G. M., Hutka, S., & Moreno, S. (2013). Tone language speakers and musicians share enhanced perceptual and cognitive abilities for musical pitch: Evidence for bidirectionality between the domains of language and music. *PloS ONE, 8,* e60676. doi:10.1371/journal.pone.0060676

Cattell, R. B., & Cattell, A. K. S. (1961/2008). *Measuring intelligence with the Culture Fair Tests*. Oxford, UK: Hogrefe.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Mahwah, NJ: Erlbaum.

De Dreu, C. K., Nijstad, B. A., Baas, M., Wolsink, I., & Roskes, M. (2012). Working memory benefits creative insight, musical improvisation, and original ideation through maintained task-focused attention. *Personality and Social Psychology Bulletin, 38,* 656–669. doi:10.1177/0146167211435795

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D. (1976). *Manual for kit of factor-referenced cognitive tests*. Princeton, NJ: Educational Testing Service.

Ericsson, K. A., Krampe, R. Th., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychological Review, 100,* 363–406. doi:10.1037/0033–295X.100.3.363

Hambrick, D. Z., Oswald, F. L., Altmann, E. M., Meinz, E. J., Gobet, F., & Campitelli. (in press). Deliberate practice: Is that all it takes to become an expert? *Intelligence*.

Hansen, M., Wallentin, M., & Vuust, P. (in press). Working memory and musical competence of musicians and non-musicians. *Psychology of Music*. doi:10.1177/0305735612452186

Howe, M. J. A., Davidson, J. W., & Sloboda, J. A. (1998). Innate talents: Reality or myth? *Behavioral and Brain Sciences, 21,* 399–442. doi:10.1017/S0140525X9800123X

Kane, M. J., Hambrick, D. Z., Tuholski, S. W., Wilhelm, O., Payne, T. W., & Engle, R. W. (2004). The generality of working memory capacity: A latent-variable approach to verbal and visuo-spatial memory span and reasoning. *Journal of Experimental Psychology: General, 133,* 189–217. doi:10.1037/0096–3445.133.2.189

Kline, R. (2004). *Beyond significance testing: Reforming data analysis methods in behavioral research*. Washington, DC: American Psychological Association. doi:10.1037/10693-000

Krampe, R. T., & Ericsson, K. A. (1996). Maintaining excellence: Deliberate practice and elite performance in young and old pianists. *Journal of Experimental Psychology: General, 125,* 331–359. doi:10.1037/0096–3445.125.4.331

Meinz, E. J., & Hambrick, D. Z. (2010). Deliberate practice is necessary but not sufficient to explain individual differences in piano sight-reading skill: The role of working memory capacity. *Psychological Science, 21,* 914–919. doi:10.1177/0956797610373933

Plucker, J. A. (1999). Is the proof in the pudding? Reanalyses of Torrance's (1958 to present) longitudinal data. *Creativity Research Journal, 12,* 103–114. doi:10.1207/s15326934crj1202_3

Pressing, J. (1988). Improvisation: Methods and models. In J. A. Sloboda (Eds.), *Generative processes in music: The psychology of performance, improvisation, and composition* (pp. 129–178). Oxford: Clarendon Press.
Silvia, P. J., & Beaty, R. E. (2012). Making creative metaphors: The importance of fluid intelligence for creative thought. *Intelligence, 40,* 343–351. doi:10.1016/j.intell.2012.02.005
Silvia, P. J., Winterstein, B. P., Willse, J. T., Barona, C. M., Cram, J. T., Hess, K. I., . . . Richard, C. A. (2008). Assessing creativity with divergent thinking tasks: Exploring the reliability and validity of new subjective scoring methods. *Psychology of Aesthetics, Creativity, and the Arts, 2,* 68–85. doi:10.1037/1931–3896.2.2.68
Thurstone, L. L. (1938). *Primary mental abilities*. Chicago, IL: University of Chicago Press.
Torrance, E. P. (1988). The nature of creativity as manifest in its testing. In R. J. Sternberg (Eds.), *The nature of creativity: Contemporary psychological perspectives* (pp. 43–75). New York, NY: Cambridge University Press.
Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the operation span task. *Behavior Research Methods, 37,* 498–505. doi:10.3758/BF03192720
Webster, P. (1990). Creativity as creative thinking. *Music Educators Journal, 76,* 22–28. doi:10.2307/3401073

Appendix A

Rater Instructions

We are primarily interested in assessing the creative quality of students' improvisation within the context of a novel harmonic structure. After viewing the videos, we ask that you rate the performances on a 7-point scale, where 1 is the lowest possible score and 7 is the highest. You may consider as many elements of the performance that come to mind (melodic development, intonation, etc.), but simply factor these into one overall, holistic score.

Appendix B

Improvisational Thinking Questionnaire Items

1. To what extent do you feel that you are in control of the direction of your playing?
2. To what extent are your improvisations guided by conscious thinking?
3. To what extent do you make decisions about what you are going to play before you play it?
4. To what extent do you plan what you will play right before you play it?
5. To what extent are your improvisations guided by feeling or emotion?
6. To what extent are previously learned melody lines or licks present in your solo?
7. To what extent do you feel that other musicians in an ensemble influence your improvisation?
8. How often do you mentally rehearse or improvise without your instrument?

Received July 26, 2012
Revision received September 3, 2013
Accepted September 30, 2013 ■