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The Effect of Jazz Improvisation Instruction on Measures of Executive Function in Middle School Band Students

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Abstract

Research investigating links between academic achievement and active music instruction has not previously differentiated between different types of instruction. In the current study, 155 seventh- and eighth-grade middle school band students were divided into two groups. Both groups received 2 months of instruction in jazz phrasing, scales, and vocabulary, but only the experimental group was taught to improvise. All instruction was part of the warm-up routine in regular band classes. All students were tested before and after instruction on the Wisconsin Card Sorting Task (cognitive flexibility) and the classic Stroop task (inhibitory control). At posttest, eighth-grade students in the experimental group scored significantly better on cognitive flexibility with a smaller percentage of perseverative errors, whereas the treatment had no effect on seventh-grade students on this outcome. Seventh graders, but not eighth graders, in the experimental group increased their posttest scores for inhibitory control, though this result was only marginally significant. In relation to previous research, the current results strongly suggest that far-transfer effects of active music participation depend on the nature of the instruction. Results of prior and future studies should therefore be interpreted in light of the type of music-making engaged by participants.

Keywords

improvisation, far transfer, cognitive flexibility, inhibition, jazz

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For over 20 years, researchers have been exploring possible links between academic achievement and active music participation in children (for reviews, see Hallam, 2010; Moreno & Bidelman, 2014). Specifically, results of longitudinal studies in which active music participation has been compared to other arts-related activities show music studies may enhance general IQ (Schellenberg, 2004), standardized test scores (Holochwost et al., 2017), linguistic abilities (Chobert, François, Velay, & Besson, 2014; Moreno et al., 2009), and verbal intelligence (Moreno et al., 2011). Yet, other evidence shows that music students do not score higher on standardized tests administered in high school (Elpus, 2013) and children do not show enhanced performance on nonmusic cognitive tasks and academic achievement after music classes (Cogo-Moreira, De Ávila, Ploubidis, & Mari, 2013; Habibi, Damasio, Ilari, Sachs, & Damasio, 2018; Sala & Gobet, 2017).

Various theoretical frameworks have been suggested to explain why active music participation may enhance academic achievement. First, active music participation may cause enhanced auditory encoding of speech (Kraus et al., 2014), but the link between this enhancement and general cognitive abilities remains unexplored. Next, Patel (2011) proposed the "OPERA" hypothesis: Music training improves auditory attention and processing, which can lead to improvements in nonmusic domains, such as language, as well as executive control and inhibition abilities (White, Hutka, Williams, & Moreno, 2013). Another prominent idea is that active music participation enhances executive function, which in turn causes higher scores on academic achievement and IQ tests; however, evidence supporting this is inconsistent (Bergman Nutley, Darki, & Klingberg, 2014; Degé, Kubicek, & Schwarzer, 2011; Schellenberg, 2011). We suggest that inconsistent results are due to a lack of differentiation between different types of music instruction. Previous research examining the effects of music experience on cognition has compared musically trained or experienced musicians to nonmusicians rather than investigating the effects of different types of music training (Hallam, 2010). One type of music training that has not been evaluated separately in previous research is instruction with a focus on musical improvisation.

Music improvisation specifically involves the ability to adapt and integrate sequences of sounds and motor productions in real time, concatenating previously stored motor sequences in order to flexibly produce a desired result, in this case, a particular auditory experience (Beaty, 2015). The created output is then evaluated by the musician in real time based on internal goals and the external environment, which may lead to the improviser modifying subsequent motor acts (Pressing, 1988). Despite the extra cognitive demands related to the integration and evaluation of novel motor sequences during musical improvisation, no studies to date have examined relationships between improvisation training and cognitive abilities. In the current study, we explore whether music improvisation training over and above a traditional concert band experience improves aspects of executive function.

Miyake and Friedman (2012) defined executive function as "general-purpose control processes that regulate one's thoughts and behavior" (p. 8). Recently, Slevc, Davey, Buschkuehl, and Jaeggi (2016) described a framework for executive function that includes three core functions: inhibition, updating, and switching. Specific executive functions have been found to be moderately correlated with each other while still remaining distinct (Miyake et al., 2000). Here, we focus on two specific constructs that previously have been associated with music performance (e.g., Degé et al., 2011): cognitive flexibility and inhibition. In addition, we discuss current research in creativity and, more specifically, relationships between musical improvisation and executive functions.

Cognitive flexibility is defined as "the general ability to adapt one's responses to the demand of the current situation and stimulate creative, novel thought" (Buitenweg, Murre, & Ridderinkhof, 2012, p. 2). Adult musicians have been found to have superior cognitive flexibility compared to nonmusicians (Hanna-Pladdy & MacKay, 2011; Moradzadeh, Blumenthal, & Wiseheart, 2015; Zuk, Benjamin, Kenyon, & Gaab, 2014), and 6 months of piano study improved the cognitive flexibility of senior citizens (Bugos, Perlstein, McCrae, Brophy, & Bedenbaugh, 2007). With regard to children, Holochwost et al. (2017) used a randomized/control design that controlled for the possibility of selection bias, finding 3 years of active music instruction improved cognitive flexibility relative to nonmusic controls. Schellenberg (2011) found no difference between the mental flexibility skills of 9- to 12-year-old musicians and nonmusicians. However, Degé et al. (2011) suggested the tests used to measure executive skills in Schellenberg (2011) were designed for adults and not for children, which could explain the null effects. Neurologic evidence shows enhanced activation in regions associated with executive functions for musically trained children (Zuk et al., 2014).

Inhibition, or inhibitory control, is the ability to selectively attend to a task, suppress thoughts or behaviors, and control actions or emotions (Diamond, 2013). It has been measured using modified Stroop tasks and go/no-go paradigms. For example, participants see the word *red* written in black ink, and they must say the color of the text ("black") rather than the actual word ("red"; Van der Elst, 2006). Musically trained children and adults have demonstrated superior inhibition ability relative to nonmusicians (Bialystok & DePape, 2009; Degé et al., 2011; Holochwost et al., 2017; Moreno et al., 2011; Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013; Travis, Harung, & Lagrosen, 2011).

Creative thinking has been characterized by bottom-up, automatic processes that may be facilitated through defocused attention and by top-down, control processes when attentional focus is advantageous (Beaty, Benedek, Silvia, & Schacter, 2016). In traditional creativity tasks, the use of defocused attention initially facilitated idea generation. This automatic processing was followed by actual idea selection, which is guided by top-down rules (Ellamil, Dobson, Beeman, & Christoff, 2012). Recent research suggests that musical improvisation may employ both processes concurrently, as automatic processes generate content that is continuously shaped by an overall control strategy (Adhikari et al., 2016; Beaty et al., 2016; Dhakal, Norgaard, Adhikari, Yun, & Dhamala, 2019; Pinho, Ullén, Castelo-Branco, Fransson, & De Manzano, 2016). In a tonal jazz setting, Norgaard (2014) suggested that learned rules and patterns guide note selection based on the tonal and rhythmic context in an automatic learned process that does not require attentional focus by an advanced practitioner (Norgaard, Emerson, Dawn, & Fidlon, 2016). Concurrently, the top-down control process is engaged in selecting patterns that fit an overall goal, such as the creation of larger pleasing musical structures and interaction with other ensemble members (Berliner, 1994; Monson, 1996; Norgaard, 2011). Qualitative data obtained from advanced jazz improvisers suggest this cognitive control process is highly flexible, whereby attentional focus can change quickly between specific tonal or rhythmic aspects (Norgaard, 2011). Indeed, flexible cognitive control has specifically been linked to creativity in other domains and investigated using the classic Stroop task. Zabelina and Robinson (2010) found that creative performance was a positive predictor of flexible cognitive control as measured by priming effects of consecutive trials in a modified Stroop task.

Researchers recently have linked the additional demands of improvised performance to structural (neurological) and behavioral changes in advanced practitioners. Zeng, Przysinda, Pfeifer, Arkin, and Loui (2017) compared white matter connectivity (myelination along the axons of neurons, thought to support speed in cognitive processing) of university jazz and classical musicians. They found higher rates of fractional anisotropy in the cingulate cortex and corpus callosum in jazz musicians, indicating more white matter organization and density (Nelson & Luciana, 2008). These differences correlated with a separate measure of improvisation achievement. Other research shows that advanced musicians' perceptual skills can be differentiated based on their background. Jazz musicians showed enhanced auditory acuity compared to classical performers (Hansen, Vuust, & Pearce, 2016; Vuust, Brattico, Seppänen, Näätänen, & Tervaniemi, 2012). In both studies, the authors speculated that the enhanced perceptual abilities were due to the improvisational component, which is essential to jazz performance (Berliner, 1994).

In the current study, we explored far-transfer effects of instruction with a focus on jazz improvisation with middle school band students. On the basis of the literature that emphasizes additional cognitive demands related to improvisation, we hypothesized that students who received instruction with a focus on improvisation would show enhanced measures of executive function. We were not able to make a specific prediction related to differential changes in executive function between seventh and eighth grades based on the literature. However, instrumental facility and general maturation presumably differ from seventh to eighth grade, so we expected that grade could be related to performance on the cognitive tests. Specifically, we investigated changes in measures of inhibitory control and cognitive flexibility as both are central to improvisational thinking. We sought to gain insight into general cognitive development through engagement with specific music activities. Furthermore, results may lead to insight specifically related to cognition underpinning music improvisation.

Method

Participants

The sample consisted of 155 seventh- and eighth-grade (generally 13 to 14 years of age) middle school band students (51 female) from one suburban school. The initial sample for the pretest included 165 students, but 10 of those students did not complete the posttest. All the students participated in concert band classes in which instruction was based on learning and performing composed music. Twenty-two of the students also participated in jazz band, where students learned to improvise solos in jazz style. In addition, 16 of the students in jazz band were involved in an intensive after-school program where extra improvisation instruction was delivered by faculty members from a nearby university.

Materials

This study utilized a battery of psychological tests found in the open-source software Psychology Experiment Building Language (PEBL; Mueller & Piper, 2014). The battery of tests included the Berg Card Sorting Test, a forward digit span, and Stroop. The PEBL software was preinstalled on Macintosh laptop computers with the Yosemite 10.10.5 operating system. The computers were brought in by the researchers and were set up on tables in the school's computer lab.

The Berg Card Sorting Test, which is more commonly known as the Wisconsin Card Sorting Test (WCST), is a measure of executive function, specifically, cognitive flexibility (Nyhus & Barceló, 2009). In a comparison between the manual and a computerized version of the test, no significant difference was found in measures of perseverative errors (Tien et al., 1996). The computer presents the participant with four key cards, which contain shapes that differ in geometric type, color, or number of shapes. The participant has to correctly match a given card to one of four displayed cards through trial and error using a sorting rule based on either type, color, or number. The participant receives feedback indicating whether the choice is correct or incorrect. After 10 correct trials, the sorting rule changes without notice, and the participant, again, must figure out how to sort the newly presented cards. The WCST is primarily scored through type of errors. The most commonly used measure is the percentage of the total number of trials with perseverative errors (Nyhus & Barceló, 2009; Piper et al., 2011). These are errors whereby participants continue using the old sorting rule after feedback indicates that the rule is no longer correct.

The digit span is used as a measure of short-term memory (Kurt, Yener, & Oguz, 2011). The participant wears headphones and the computer recites a list of single-digit numbers, which the participant then must type into the computer. The list begins with two numbers and increases as the participant inputs the correct numbers. When the participant begins to input incorrect answers, the test is completed.

The Stroop test is a general measure of executive function, specifically, inhibitory control (Van der Elst, 2006). In this test, the computer shows words written in different colored ink. The participant indicates the color of the word, not the text, using the numerical keypad on the keyboard. This test has three different type of trials: congruent, incongruent, and neutral. A congruent trial is when the color of the ink matches the text of the word, a neutral trial is when the color and the text of the word have no relation, and an incongruent trial is when the color and the text of the word do not match. The average increase in response time to indicate ink color in incongruent trials compared with the neutral trials is referred to as the "Stroop inhibition effect," and the average decrease on congruent trials compared to neutral trials is considered a measure of "facilitation" (Macleod, 1991).

Finally, we used composite scores from the Iowa Test of Basic Skills to control for academic achievement. This test was administered by the school as part of students' general testing regimen. The eighth graders in the current study took this test in October 2015, prior to the intervention described later. The seventh graders in the current study took the test the following year, when they had advanced to eighth grade. This allowed us to use the exact same test as a covariate for all participants independent of grade level. While in seventh grade, participants did not take the Iowa Test of Basic Skills as part of school-administered achievement testing. Instead, they took a test specific to the state in which the school is located. It was not possible to administer the Iowa Test of Basic Skills to seventh graders concurrently as part of this study due to the time involved with that battery of tests.

Procedure

Upon receiving approval from the university's institutional review board and the participating school district, recruitment began for this study during the fall semester of the 2015–2016 school year. Child assent and parental consent forms were collected from all participants, and testing began during the end of the fall semester. All tests were administered during the students' regular school day. Groups of students were divided in testing groups, depending on the class period in which they participated in concert band. Students came to their regular computer lab and took the three tests—digit span, WCST, and Stroop—on the laptops brought by the researchers. Before the testing began, the researchers explained the procedures and allowed students to ask related questions. The tests took on average 25 min for students to complete. During this time, the computer lab remained silent and there were no interruptions. The pretest was administered in November 2015, and the posttest in May the following year.

We devised an instructional intervention that was given to all the students in concert band over 2 months during spring of 2016. The band director and assistant band director of the school taught all the students in four separate classes: seventh-grade woodwinds, seventh-grade brass and percussion, eighth-grade woodwinds, and eighth-grade brass and percussion. For the music training control (MUS) group, we provided guidelines for a curriculum of jazz articulation and exercises (scales and patterns) required to improvise, but the students in this group never actually improvised. The experimental improvisation training (IMP) group received the same articulation and pattern instruction but with the added element of using the scales and patterns to improvise. Both interventions were conducted as part of the class warm-up activities for about 10 min in each class over a 2-month period. As the improvisation training included additional activities, the time spent on the improvisation training was slightly longer than the scale warm-up in the MUS group. However, total instruction time, including warm-up activities and repertoire practice, was exactly matched between the two groups as class periods were the same length. The curriculum was designed by the band directors and included traditional call-and-response activities. We observed and audio recorded the classes three times to assure that the curriculum followed our guidelines (for details, see the supplemental materials included with the online version of this article). Two of the four classes learned to improvise: seventh-grade woodwinds and eighth-grade brass and percussion classes. We were not able to assign individual students to experimental and control groups randomly as class schedules dictated group assignments. The 22 students who had previous experience with improvisation in jazz band and the after-school jazz program were separated out in the analysis (JAZZ group). At the end of the spring semester, a posttest was administered to all students following the same procedures used for the pretest. In addition to the computerized tests, for the posttest we also asked students for two ratings, jazz experience during the semester and "comfort" with improvisation: "On a scale from 1 to 10, how much experience with jazz improvisation have you had since January?" (1 = *none*, 10 = *a lot*). "On a scale from 1 to 10, how comfortable do you feel improvising?" (1 = *not at all*, 10 = *very comfortable*).

Results

Pretest

Before the treatment, we analyzed existing differences in the initial sample ($N = 165$) between concert band students ($n = 141$) and the students who also received training in jazz improvisation prior to the study ($n = 24$) by comparing the means of the dependent variables from the three tests of executive function using three independent-samples t tests. The jazz students had a significantly lower percentage of perseverative errors ($M = 11.85$, $SD = 3.17$) than the other band students ($M = 14.75$, $SD = 6.55$), $t(63.09) = -3.42$, $p = .001$, $d = .44$ (equal variances not assumed). However, there were no significant differences between the two groups in Stroop interference scores and digit span. This pretest included widely different group sizes, and the assumption of equal variances for the t test was violated. In addition, 10 of the students included here did not complete the posttest and the Iowa Test of Basic Skills and, therefore, were not part of the main analysis.

Main Results

The total number of students who completed all cognitive pre- and posttests as well as the Iowa Test of Basic Skills was 155, and the group sizes were as follows: seventh-grade, IMP $n = 35$, MUS $n = 41$, JAZZ $n = 9$; eighth grade, IMP $n = 36$, MUS $n = 21$, JAZZ $n = 13$. To assure the students' subjective experience of the treatments was different between the IMP and the MUS group, we conducted an independent-samples t test on the students' posttest ratings. We found the IMP group rated "experience with jazz improvisation since January" significantly higher ($n = 71$, $M = 7.04$, $SD = 1.67$) than the MUS group ($n = 62$, $M = 3.60$, $SD = 2.60$), $t(102.13) = 8.94$, $p < .001$, $d = 1.6$ (equal variances not assumed). Similarly, the IMP group rated "how comfortable do you feel improvising" significantly higher after treatment ($n = 71$,

$M = 6.18$, $SD = 2.04$) than the MUS group ($n = 62$, $M = 3.97$, $SD = 2.60$), $t(131) = 5.50$, $p < .001$, $d = .96$. Because ratings of "comfort" with jazz improvisation may depend on gender (Wehr-Flowers, 2006), we conducted a between-subjects analysis of variance on comfort scores with treatment (MUS, IMP, JAZZ) and gender (male, female) as factors. Indeed, we found a significant main effect of gender, $F(1, 149) = 9.97$, $p = .002$, $\eta_p^2 = .063$, but no interaction between gender and treatment, $F(2, 149) = .679$, $p = .509$, $\eta_p^2 = .009$. Post hoc analysis indicated that the effect was largely driven by a difference between the comfort ratings in the MUS group, with males indicating higher comfort level ($n = 38$, $M = 4.53$, $SD = 2.76$) than females ($n = 24$, $M = 3.08$, $SD = 2.08$), $t(57.96) = 2.34$, $p = .023$ (a priori alpha set at .017 for multiple comparisons).

To investigate differences in executive function after the improvisation training, we conducted a repeated-measures analysis of covariance (ANCOVA) for each of the dependent variables. We added the following factors: time (pre- and posttreatment), grade level (seventh and eighth grades), and treatment (MUS, IMP, JAZZ). The dependent variables of percentage perseverative errors and increase in inhibition response time were tested for the assumption of normality. Visual inspection of the histograms and Shapiro-Wilk tests ($p > .05$) confirmed this assumption was largely met. We controlled for academic achievement by using the composite scores from the Iowa Test of Basic Skills as a covariate. Independence of the covariate and the treatment effect was established by comparing the covariate across the three treatment groups ($p = .193$). To measure changes in cognitive flexibility, we analyzed perseveration scores on the WCST. Thirteen students were eliminated from the analysis as they failed to comprehend the WCST task instructions as evidenced by extreme outlying error scores (Lyvers & Tobias-Webb, 2010). There was a significant main effect of time, with all students scoring significantly better with a lower percentage of perseverative errors after treatment ($M = 11.89$, $SD = 3.93$) than before ($M = 14.32$, $SD = 5.77$), $F(1, 135) = 17.87$, $p < .001$, $\eta_p^2 = .117$. The interaction between time and treatment was not significant, $F(2, 135) = 2.42$, $p = .093$, $\eta_p^2 = .035$, indicating the treatment appeared to have no effect on percentage of perseverative errors. However, there was a significant three-way interaction between time, treatment, and grade level, $F(2, 135) = 3.12$, $p = .047$, $\eta_p^2 = .044$. We therefore conducted post hoc analyses to see if the treatment effect was different depending on grade level (described later).

To test for differences in measures of inhibition using the Stroop task, we again ran repeated-measures ANCOVAs with the same factors as named previously but with inhibition time as the dependent variable. This measure of inhibition showed no main effect of time, $F(1, 148) = .131$, $p = .718$, and the interaction of time and treatment was also not significant, $F(2, 148) = 2.27$, $p = .107$. But again, we found a significant three-way interaction between time, treatment, and grade level, $F(2, 148) = 3.22$, $p = .043$, $\eta_p^2 = .042$. Therefore, we included inhibition in the post hoc analysis. There were no main effects or significant interactions on measures of facilitation. Finally, to assure that the observed effects were not related to differences in working memory capacity between the groups, we ran a similar analysis of changes in scores on the forward digit span. There were no main effects of time and no significant interactions.

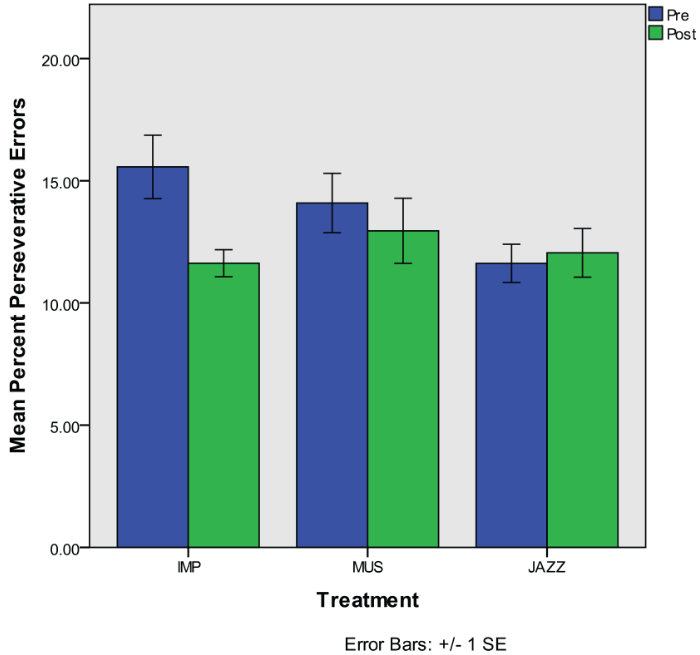

Figure 1. Mean percentage perseverative errors for eighth grade students. Students in the IMP had significantly fewer errors after treatment. No differences were found in the MUS and JAZZ groups. Error bars represent +/–1 standard error.
Note. IMP = improvisation training group; MUS = music training control group; JAZZ = students in jazz band and after-school jazz program.

We conducted post hoc repeated-measures *t* tests for the MUS and the IMP groups on the two dependent measures for which a significant three-way interaction was identified in the main analysis. We adjusted the alpha level for multiple comparisons using the Šidák adjustment for four groups: seventh-grade IMP and MUS and eighth-grade IMP and MUS: $1 - (1 - .05)^{1/4} = .0127$, resulting in an alpha value set to .0127. We did not include the JAZZ group in the post hoc analysis as those students improvised prior to treatment. For the WCST, we found no difference between the two groups in seventh grade as both the IMP group, $t(30) = 3.48$, $p = .002$, and the MUS group, $t(37) = 3.36$, $p = .002$, showed significant improvement. However, we did see a difference due to the treatment in eighth grade (Figure 1) in which only the IMP group scored significantly better, with a lower percentage of perseverative errors after treatment ($n = 34$; pretest, $M = 15.57$, $SD = 7.57$; posttest, $M = 11.63$, $SD = 3.23$), $t(33) = 3.38$, $p = .002$, whereas the MUS group's scores did not change significantly ($n = 19$; pretest, $M = 14.09$, $SD = 5.29$; posttest, $M = 12.95$, $SD = 5.81$), $t(18) = 1.14$, $p = .271$. Interestingly, we saw a similar trend for improved inhibition for the IMP group only, but for seventh graders, not eighth graders, although this result was only marginally significant. In seventh grade, the IMP group scored better, as response times got faster after treatment (n = 35; pretest, M = 92.64, SD = 66.23; posttest, M = 64.41, SD = 65.24), but the change only approached significance, $t(34) = 2.31$, $p = .027$. The MUS group scored worse, with slower response times (n = 41; pretest, M = 77.59, SD = 81.26; posttest, M = 92.38, SD = 66.25), and the change was not significant, $t(40) = -1.16$, $p = .251$. For eighth grade, none of the groups scored significantly different on the inhibition measure after training.

Discussion

In this study, we investigated the far-transfer effects of music improvisation instruction on measures of executive function, including cognitive flexibility, inhibition, and facilitation. In a pre/posttest design, we administered the WCST, the Stroop task, and the forward digit span in November and again the following May to band students in seventh and eighth grades. Between testing, all students learned about jazz phrasing and scales, but only students in the experimental improvisation training groups were asked to improvise with those scales. Finally, the band program included a small group of students who were in jazz band and in an intensive after-school jazz program. These students therefore had improvisation training prior to the pretest.

The results of this investigation show that improvisation training may have different effects on executive function depending on students' grade level. In seventh grade, the results show that improvisation training enhanced students' ability to inhibit irrelevant information, although this change was only marginally significant. Inhibition traditionally is associated with creativity in that new ideas are favored, whereas old, stereotypical ideas are inhibited. This is consistent with the recent finding that performance on general measures of creativity are linked with an absence of the Stroop effect—the traditional increase in processing time on incongruent trials (Edl, Benedek, Papousek, Weiss, & Fink, 2014). In the current study, the seventh-grade students were beginning improvisers who may not have a library of stereotypical ideas they are trying to inhibit. In this case, the instructor developed improvisation by asking students first to repeat the instructor's ideas and then to make up new ideas. As the students were creating their own ideas, they had to inhibit the model idea just given.

Interestingly, the results showed no effect of inhibition with eighth-grade students but instead a significant change in cognitive flexibility. Although both the improvisation students and the control group had fewer perseverative errors in the post measure, only the IMP students improved significantly. This improvement mirrored the performance of the JAZZ students (see Figure 1). In addition to the call-and-response activity, the eighth graders may have been more engaged directly with tonal jazz improvisation due to their advanced technique compared to the seventh graders. Tonal jazz improvisation involves creating melodic material that fits a given rhythmic and harmonic framework. The eighth graders may have been able to focus specifically on how their improvised output related to the accompaniment. For example, particular notes may sound consonant or dissonant depending on the relationship to the accompanying chords. This real-time evaluation of output according to tonal convention may result in quick adjustments that may train cognitive flexibility—"the general ability to adapt one's responses to the demand of the current situation and stimulate creative, novel thought" (Buitenweg et al., 2012, p. 2).

There are several other possible explanations for the divergent results seen between seventh and eighth grades. One explanation relates to music performance level or dosage effects of how many years students played their instrument. In findings similar to ours, Holochwost et al. (2017) found 2 years of instrument playing improved performance on the Stroop task, but 3 years was needed for gains on the WCST. Next, the task demands may have varied between grade levels. In both grade levels, the concert band students in the IMP group were beginners as related to improvisation but not to overall instrumental technique. By the end of eighth grade, the vast majority of the students would have had nearly 3 full years of band instruction. They would therefore be playing on a level in which the technical demands of the improvisation exercises would be relatively lower than the demands for the seventh-grade students. Authors of future research could explore why this change in technical ability may cause different far-transfer effects from the same improvisation activities. Specifically, a longitudinal design could be used to follow the same students as they progress through various grade levels and develop technical proficiency to see if far-transfer effects change over time.

Another possibility is that the observed differences in far-transfer effects are related to students' engagement with the task. Anecdotal evidence gathered from recordings of selected improvisation activities showed a hesitation by eighth graders to improvise compared to seventh graders. Accounts from pedagogues of improvisation support this notion. As students become more advanced through traditional exercises based on reproductive performance, they are more apprehensive about learning a new skill, like improvisation, in which they again may feel like beginners (Norgaard, 2017). One could speculate that it is this process of negotiating challenges related to a new skill that caused a change between the improvisation and control groups in eighth grade. Future research could match the two groups better by adding new and challenging nonimprovisatory activities to the control group.

It is also possible that task engagement was influenced by feelings of anxiety. Prior research has shown that students may feel anxiety toward learning to play and improvise in jazz style. This effect was significantly more pronounced among female students (Wehr-Flowers, 2006), although a later study with string students did not replicate this result (Alexander, 2012). Although our experimental and control groups were fairly well matched for gender, both groups had almost twice as many males as females. Like Wehr-Flowers' (2006) results, females in both groups had lower "comfort" scores than did the males, although only the difference in the MUS group was marginally significant.

Finally, it is possible that the observed differences between seventh and eighth grades were simply caused by limitations related to experimental design. In order to administer the instruction as part of the students' regular band classes, it was necessary to use preexisting instrumental groups. The seventh-grade experimental IMP group, therefore, was all woodwinds, and the eighth-grade IMP group was brass and percussion students. The main differences between woodwinds and brass relate to how sounds are produced. Furthermore, woodwinds are played bimanually. However, the eighth-grade experimental group included both brass and bimanual percussion instruments, and Duerr (2016) found instrument family was not significantly correlated to executive function of fourth-grade beginning band students (r_s = .13). Nonetheless, authors of future research should use random assignment and aim for mixed instrumentation in experimental and control groups. Another limitation of the current study is the lack of information about individual improvisation achievement. Even though self-reports by students in the IMP group indicated they were more comfortable with improvisation after treatment than did students in the MUS group, no individual measure of this improvement was collected. Authors of future research should include improvisation playing tests and could investigate if this measure is correlated with far-transfer effects. One final limitation is that the academic achievement data used as a covariate were collected at different times for seventh- and eighth-grade students. Authors of future studies should collect academic achievement data at the same time for all groups.

The results of the current study indicate that music instruction with an emphasis on improvisation may improve aspects of executive function. Music instruction has many elements. It is unclear from previous research if far-transfer effects are related to specific elements emphasized during instruction. For example, it is possible that instruction with a focus on learning music by ear has a different effect than instruction using notation. Similarly, one-on-one instruction could produce different far-transfer effects than group instruction. Prior research related to cognitive benefits of music instruction has only compared musicians to nonmusicians. The current data indicate that future research should use a less dichotomous approach. Finally, our results suggest that a small difference in warm-up procedures could change some aspects of students' executive functioning. In particular, the inclusion of improvisation activities may be beneficial to students. We therefore suggest that teachers in large performance ensembles consider adding improvisation activities to their curriculum.

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