Archives of Scientific Psychology 2018, 6, 178–192
DOI: http://dx.doi.org/10.1037/arc0000048

2169-3269

American Psychological Association

Archives of Scientific Psychology

www.apa.org/pubs/journals/arc

Cognitive Effects of Music and Dance Training in Children

Annalise A. D'Souza and Melody Wiseheart
York University

ABSTRACT

The idea that learning music can make a child smarter has gained considerable attention from parents, educators, and policymakers. Intuitively, learning to play an instrument is mentally challenging and is thought to generalize to nonmusic improvements. This claim offers promise in using music to enhance mental performance, but before it can be applied to areas such as education and cognitive remediation, the reliability of musical effects must be established. Early research indicated that musicians outperformed nonmusicians on a range of psychological abilities beyond music processing. Alternatively, because better mental ability could also result from other training activities or an individual's background characteristics, any conclusions on musical training were still premature. In fact, although some recent studies that provided musical training to nontrained children did show small mental improvements after a few weeks of training, most well-designed studies that trained nonexperts failed to find any of the benefits previously seen in expert musicians. In the current study, children aged 6 to 9 years old were given 3 weeks of music or dance lessons and measured on mental performance before and after training. To test for training-induced change, performance before and after training was compared with a nontrained group. To test whether learning music itself caused change, performance in trained groups was compared with each other, because dance is a similarly challenging skill and shares training features with music. No training effects were observed on any tested cognitive ability, which questions whether mental enrichment can occur from short-term training.

SCIENTIFIC ABSTRACT

Musical training is popularly believed to improve children's cognitive ability. Early research evidence, mostly correlational, suggested that musicians outperform nonmusicians on many cognitive abilities. However, recent experimental evidence has failed to replicate most benefits, leaving it unclear whether previously demonstrated effects were a direct result of learning music. Although a few studies have shown some change with as little as a few weeks of training, the

This article was published November 15, 2018.

Annalise A. D'Souza and Melody Wiseheart, Department of Psychology and LaMarsh Centre for Child and Youth Research, York University.

The authors have made available for use by others the data that underlie the analyses presented in this article (D'Souza & Wiseheart, 2018), thus allowing replication and potential extensions of this work by qualified researchers. Next users are obligated to involve the data originators in their publication plans, if the originators so desire.

This research was supported by Grant 410–2010-2747 to Melody Wiseheart from the Social Sciences and Humanities Research Council of Canada. The study was approved by the York University Human Participants Review Sub-Committee, e2008-177. Data have been previously presented at two conferences (D'Souza & Wiseheart, Development Conference, Ottawa, Ontario, Canada, May 2014; Puckering, D'Souza, & Wiseheart, Canadian Society for Brain, Behavior and Cognitive Science Annual Meeting, Toronto, Ontario, Canada, July 2014), and in a master's thesis by Annalise A. D'Souza (*Effects of Music and Dance Training on Executive Functions in Children*, 2013). We thank our Fine Arts faculty collaborators and teachers (Hannah Luviano, Michael Marcuzzi, Rachel Muehrer, Tracey Norman, Lisa Sandlos) for designing and delivering the training curriculum. We thank research assistants (Galit Blumenthal, Katherine Descours, Rachita Saini, Lee Unger) for data collection and coding, and class volunteers for helping deliver the training (Marlene Almeida, Nooshin Davar, Kayla Dawson, Mahta Kakvan, Nakeesa Kooshafar, Pariah Mirazimi, Andrea Murua, Mearon Naman, Andrew Oh, Zina Rakhamilova, Pouya Rostami, Rachita Saini, Sahar Tabrizi, Rida Waseem, and Ariella Winter). We thank the Cognitive Flexibility Lab for input throughout all stages of this study.

Correspondence concerning this article should be addressed to Melody Wiseheart, Department of Psychology, York University, 4700 Keele Street, Toronto, ON M3J1P3, Canada. E-mail: melodywiseheart@gmail.com

larger training literature shows that transfer of skills between unrelated areas is extremely rare, especially in properly controlled studies. The current study used an experimental design to assess the cause (whether music uniquely produces change) and the effect (which cognitive abilities are impacted) of the link between music and cognition. Six- to 9-year-old children ($n = 75$) with no prior training were randomly allocated to 3 weeks of music or dance training. Cognitive performance before and after training was compared between trained groups, because both training forms share features of training plus a nontrained control group to isolate training-induced change from normal maturation. No changes were found on any measured ability (inhibitory control, working memory, task switching, processing speed, receptive vocabulary, and nonverbal intelligence). Findings confirm evidence from the general training literature that training-induced improvements on cognitive performance are unlikely. Short-term training effects have a much narrower scope than previous evidence suggests.

Keywords: music, dance, cognition, task switching, training
Supplemental materials: http://dx.doi.org/10.1037/arc0000048.supp
Data repository: https://doi.org/10.3886/ICPSR37080.v1

Over the past few decades, the idea that musical training improves mental functioning has gained popularity in research and public spheres. Supporting this notion, a body of early research evidence demonstrated that musicians outperform nonmusicians across psychological measures. Neuroimaging evidence also found substantial structural and functional differences in the brains of musicians, such that musicians were often described as a model for neural plasticity (Jäncke, 2009; Münte, Altenmüller, & Jäncke, 2002; Rodrigues, Loureiro, & Caramelli, 2010). In contrast to early findings, recent evidence has repeatedly failed to replicate a musician advantage, especially when using better methodology, leaving it inconclusive as to whether musical training influences cognition (Mehr, 2015; Sala & Gobet, 2017b).

If effects did exist, what it is about music that causes benefits remains an open question. The implied process, whereby learning in one situation influences performance in another situation, is termed *transfer of skills* or *generalizability of learning* (Royer, Mestre, & Dufresne, 2005; Singley & Anderson, 1989). Transfer can be conceptualized as a similarity continuum, whereby near transfer refers to change on skills that closely resemble the training domain and far transfer to skills with little overlap with the training domain (Barnett & Ceci, 2002). The amount of observed transfer is a function of the overlap between trained and measured abilities (Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010; Morris, Bransford, & Franks, 1977; Thorndike & Woodworth, 1901). Demonstrations of near transfer between related skills are common, whereas far transfer, such as from skill learning to cognition, is rare (Green & Bavelier, 2008; Noack, Lövdén, Schmiedek, & Lindenberger, 2009; Slagter, Davidson, & Lutz, 2011).

Musical Training and Cognition

As would be expected, musicians show near transfer to abilities trained in music—for example, auditory and motor performance (Schellenberg, 2016). Beyond similar abilities, musicians show far transfer to extramusical abilities such as linguistic aptitude, mathematics, vocabulary, and visuospatial ability. Improvements on different cognitive abilities have been separately demonstrated but could be combined to propose that music has a general benefit across cognitive abilities (Schellenberg, 2009).

Early studies found that receiving music lessons enhanced general intelligence (Schellenberg, 2004, 2006). These studies were used to support a general benefit of music, with general intelligence as the candidate underlying the effect. However, subsequent investigations on intelligence in musicians failed to replicate effects across intelligence tests (verbal and nonverbal intelligence, full-scale IQ; Mehr, Schachner, Katz, & Spelke, 2013).

Another proposed ability underlying a general benefit is executive functions, higher order cognitive abilities for goal-related behavior such as working memory, inhibition and interference control, task switching, and planning (Diamond, 2013; Diamond & Lee, 2011; Miyake et al., 2000). Music may influence executive functions, which then influence general intelligence, thus mediating a general cognitive effect (Hannon & Trainor, 2007). Evidence for a mediation is unsettled (Degé, Kubicek, & Schwarzer, 2011; cf. Schellenberg, 2011), but a link between music and separate executive functions has received some support. Correlational studies have found that expert musicians have better performance than their nontrained counterparts across different measures (simple and complex) and subdomains of working memory (auditory, visuospatial, and the central executive), whereas others have found it only on certain measures or not at all (Lee, Lu, & Ko, 2007; cf. Hansen, Wallentin, & Vuust, 2013; Roden, Grube, Bongard, & Kreutz, 2014; Slevc, Davey, Buschkuehl, & Jaeggi, 2016). Similarly, inhibition benefits have been found on some tasks but are not always replicated (cf. Bugos, 2010; Janus, Lee, Moreno, & Bialystok, 2016; Joret, Germeys, & Gidron, 2017; Slevc et al., 2016). Task switching has demonstrated the most consistent benefits (Degé, Wehrum, Stark, & Schwarzer, 2011; Hanna-Pladdy & MacKay, 2011; Isaacs & Trofimovich, 2011; Zuk, Benjamin, Kenyon, & Gaab, 2014).

We suggest a that third candidate for general benefits is processing speed. Like general intelligence and executive functions, processing speed is theorized to underlie performance across many cognitive tasks (Salthouse, 1993, 1996). Like the other abilities, processing speed improvements have also been found in musicians (Bugos, 2010; Bugos & Mostafa, 2011; Roden, Könen, et al., 2014). However, because a musician advantage is not always replicated across studies, nor across measures in a single study, a general cognitive benefit from music is unlikely. Further, a cognitive advantage in musicians does not always translate to real-world improvement on academic success (Cox & Stephens, 2006; Fitzpatrick, 2006; Isaacs & Tromovich, 2011), as would be expected if a general effect existed.

The Need for Experimental Trials of Musical Training

The majority of music studies share a fundamental limitation: the use of correlational or quasi-experimental designs that compare musicians with nontrained individuals. This nonexperimental evidence does not rule out alternate explanations such as reverse causality (i.e., children with better cognition take music) or nonmusical factors that also impact cognitive performance. Musicians differ from nonmusicians on several background characteristics other than musical training—for example, socioeconomic status, genetically inherited cognitive ability, and an academic self-concept, any of which could have produced purported training effects (Degé, Wehrum, Stark, & Schwarzer, 2014; Mosing, Madison, Pedersen, & Ullén, 2015).

Many researchers have highlighted the need for rigorously controlled trials to confirm whether musical training itself causes observed benefits (Črnčec, Wilson, & Prior, 2006; Hargreaves & Aksentijevic, 2011; Mehr et al., 2013; Merrett, Peretz, & Wilson, 2013; Rodrigues et al., 2010; Schellenberg & Winner, 2011; Slevc et al., 2016; Zuk et al., 2014). The few studies that used an experimental design provide a different picture than that suggested by nonexperimental evidence. The majority of experimental designs have failed to consistently replicate better intelligence from musical training (Mehr et al., 2013). Limited benefits have been experimentally demonstrated on some cognitive abilities with as little as a few weeks of training (Janus et al., 2016; Moreno et al., 2011; cf. Mehr et al., 2013).

A recent critical review failed to find conclusive support for benefits of music interventions on child cognitive development (Dumont, Syurina, Feron, & van Hooren, 2017). A meta-analysis of experimental evidence in children similarly concluded that musical training does not reliably impact general cognitive ability, but benefits on individual abilities were supported (Sala & Gobet, 2017b). The strongest effect sizes were for measures of memory and intelligence, with a small effect size on a few other cognitive measures (mathematics, reading, and visuospatial ability). Importantly, there was an inverse relationship between effect size and methodological quality, highlighting the value of experimental designs.

Reasons for Transfer of Training Effects From Music

For the cases in which a musician advantage has been documented, a question that follows is why music elicits changes in cognition. Existing music research has examined trained groups on extant cognitive measures and anticipated training effects with little discussion of why music may elicit extramusical effects (Gazzaniga, 2008). Implicitly or explicitly, researchers have assumed that the improved cognition observed in musicians results from musical training itself. Because music is a mentally challenging activity, it is plausible that the cognitive effort inherent to learning music could extend to cognitive performance outside the musical domain.

Independent streams of research outside the musical training literature have suggested that other forms of training can also augment cognition (Green & Bavelier, 2008; Sala & Gobet, 2017a; Slagter et al., 2011). Although far transfer to cognition is rare for all training types, activities that successfully demonstrate enhancements are characterized by general features of training such as enhanced mood, progressive difficulty, maintaining arousal and motivation, and provision of feedback. In contrast, studies that directly compared training showed that cognitive benefits from learning music are not always equaled by other activities such as drama, natural science, speaking a second language, visual arts, or other leisure activities, even after being matched on structural and general training features (D'Souza, Moradzadeh, & Wiseheart, in press; cf. Janus et al., 2016; Moradzadeh, Blumenthal, & Wiseheart, 2015; Roden, Grube, et al., 2014; Roden, Könen, et al., 2014; Seinfeld, Figueroa, Ortiz-Gil, & Sanchez-Vives, 2013). Differential benefits between training types were found—music had cognitive benefits not seen in drama or visual arts, whereas other training types had benefits on noncognitive abilities (social skills in drama and visuospatial ability in visual arts; Moreno et al., 2011; Schellenberg, 2004) that were not seen with music, suggesting that the effects may be specific to musical training.

Musical training can be divided into fundamental elements specific to music, such as pitch and timbre ("body, space, time, energy, and relationship"; Ontario Ministry of Education, 2009, p. 18). Most researchers have suggested that coordination of these elements produces benefits. Musicians learn to coordinate these elements simultaneously across sensory modalities (auditory, visual, tactile), across time, and for differing levels of performance (Moreno & Bidelman, 2014; Pearce & Rohrmeier, 2012). Coordinating multimodal demands is hypothesized to recruit top-down goal-directed cognitive processes when learning music (Hannon & Trainor, 2007). High levels of cognitive abilities have been proposed for many aspects of music, such as to monitor performance and make changes (Kaganovich et al., 2013), switch between auditory streams (Loehr, Kourtis, Vesper, Sebanz, & Knoblich, 2013), attend to timing and rate change (Loehr, Large, & Palmer, 2011), and adjust to other performers (Palmer & Deutsch, 2013). Similar cognitive transfer has been found from musical training and training of attention (Neville et al., 2008).

Rhythm entrainment also has been proposed as a mechanism for moderating the effects of music on cognition, particularly executive functions (Miendlarzewska & Trost, 2014; Portowitz, Lichtenstein, Egorova, & Brand, 2009). Rhythm entrainment involves multimodal coordination but specifically in synchrony to an external beat or rhythm (Opacic, Stevens, & Tillmann, 2009). Learning to control movement to timing in music transfers to other domains, such as from auditory to visual (Aagten-Murphy, Cappagli, & Burr, 2014), and may transfer to cognitive benefits (Hansen et al., 2013). Both multimodal coordination and rhythm entrainment characterize musical training but not other skills they were compared with (e.g., drama, natural science, visual arts), hence are possible explanations for why musical training demonstrated benefits. To test the uniqueness of musical training, the current study compares it with dance, a complex art form that overlaps with these proposed mechanisms but is separate from the key elements of music.

Dance Training and Cognition

Like music, dance training has demonstrated near and far transfer to nontrained abilities. Correlational studies found augmented performance in dancers compared with nondancers on composite measures of cognition but not on single measures of working memory, inhibition, or cognitive flexibility (Gondola, 1987; Kattenstroth, Kalisch, Holt, Tegenthoff, & Dinse, 2013; Kattenstroth, Kolankowska, Kalisch, & Dinse, 2010; Verghese, 2006). Randomized controlled trials found that dance training can cause improvements in task switching but not interference control (Coubard, Duretz, Lefebvre, Lapalus, & Ferrufino, 2011; Kimura & Hozumi, 2012; McKee & Hackney, 2013).

A meta-analysis showed limited evidence that learning to dance is accompanied by higher nonverbal reasoning skills, including intelligence, but studies were unpublished and of poor quality, so no strong conclusions can be drawn (Keinänen, Hetland, & Winner, 2000). Overall, as with music, there is limited empirical evidence suggesting cognitive benefits from learning dance. Although a musician benefit has been demonstrated across children, adults, and older adults, existing dance studies have only tested elderly participants, making the generalization to other age groups uncertain.

Like music training research, dance training can be characterized into fundamental elements specific to dance, such as body and space ("body, space, time, energy, and relationship"; Ontario Ministry of Education, 2009, p. 18). Although these are different from the elements trained in music, learning to combine these elements is similar to music, as it involves simultaneous coordination across sensory modalities (auditory, visual, tactile), across time and for differing levels of performance. As with music, coordinating multimodal demands is hypothesized to recruit top-down goal-directed cognitive processes, in this case, to organize perception and movement (Bläsing et al., 2012; Dhami, Moreno, & DeSouza, 2015; Foster, 2013; Olsson, 2012; Strait, Slater, O'Connell, & Kraus, 2015). Synchronizing cognitive and motor activity in dance has been shown to transfer to the cognitive process of dual-tasking (Hamacher, Hamacher, Rehfeld, Hökelmann, & Schega, 2015), which parallels a dual-tasking benefit seen in musicians (Moradzadeh et al., 2015).

A more specific overlap in training components between dance and music is rhythm entrainment. Like music, dance involves a sequenced hierarchical structure arranged in space and time and entrained to auditory sounds (Opacic et al., 2009; Sevdalis & Keller, 2011). Auditory and temporal stimuli (music, a beat, or sounds) are used in dance to cue movements to a rhythm. Importantly, programs with the exactly same movements as dance but not in a sequence do not show cognitive effects (Kimura & Hozumi, 2012; Satoh et al., 2014).

On one hand, music and dance can be characterized by different elements. On the other, they overlap in requiring effort for coordinating the individual elements (as proposed by mechanisms of multimodal coordination and rhythm entrainment). Both forms of training have also been linked to cognitive benefits. The similarity and differences between music and dance can be used to test the uniqueness of previously demonstrated effects of musical training. The current study investigated two main research questions related to the hypothesis of a musician advantage—that is, that music training influences cognition:

1. Music training produces general cognitive benefits: A hypothesized musician advantage assumes that musical training has a general effect on cognition. Using a large battery of cognitive tasks, changes in cognitive performance before and after training may have been demonstrated across all abilities measured (a general effect), some abilities (a specific effect), or none (no effect).

2. Music training uniquely influences cognition: A hypothesized musician advantage also assumes that effects of musical training are uniquely caused by music. By comparing musical training with dance training and no training in arts-naïve individuals, we could test whether any training effects were similar to both forms (because of shared features of music and dance training) or differential (because of music-specific features).

The null hypothesis for both questions predicted that trained and control groups should not differ on any of the cognitive abilities measured. Any previously observed benefits were because of a lack of controlled designs and are likely to have been caused by factors other than training that differentiated trained individuals from untrained individuals. The body of correlational evidence on cognitive benefits from music and dance training suggested that some benefits may be possible, but benefits have been inconsistently demonstrated across studies. The recent increase in null results from carefully controlled trials, and the small scope of cognitive transfer in the training literature also challenge previous correlational evidence to suggest that no training effects may exist.

Method

Participants

Seventy-five typically developing children aged between 6 and 9 years old from monolingual communities in Ontario, Canada, (Statistics Canada, 2007a, 2007b) took part in the study. All children assented to participate, and a parent or guardian provided informed consent. An a priori power analysis[1] was used to select the sample size that would provide at least 95% power. Participant characteristics are presented in Table 1. Training groups did not differ significantly on any background variables (age, sex, years of mother's education, preintervention nonverbal IQ) or on the unit of delivery (training site/location; all $ps > 0.1$), so these factors were collapsed in subsequent analyses.

Participants were randomly assigned to either music or dance training groups after stratifying for age, nonverbal intelligence, and gender. The training groups were not significantly different from each other on the dependent variables ($ps > .250$), except on the Flanker task ($p = .020$). As a baseline comparison, a passive control group was collected from the same recruitment locations using the same exclusion criteria. The control group was not statistically different from the training groups on any of the dependent variables prior to the intervention ($ps > .250$), making it a suitable comparison despite the lack of random assignment.

Materials and Procedure

Training curriculums were designed using national guidelines to enable age-appropriate, externally valid, and standardized programs (Ontario Ministry of Education, 2009). Lesson plans are available in Files A and B of the online supplemental materials. Each program focused on teaching the core elements for the training domain (Ontario Ministry of Education, 2009, p. 18).

The music program taught instruments (ukuleles, steel drums, and a xylophone) and singing, and the dance program taught movement. Temporal training was common to both programs. A percussion instrument was used in both to count timing. Structure was common to both programs, via duration, harmony, and form in music, and space, time, and relationship in dance. Motor control was common to both programs, using instruments in the music program and one's body in dance. Sound was also common in both programs, although it was directly trained in music (development of auditory skills by focusing on pitch, dynamics and other expressive controls, timbre, and harmony) and as an ancillary in dance (for movement to a beat and physical expression informed by the tone of the music). Finally, these elements were combined in both programs to produce synchronized movements based on timing and structure (rhythm entrainment), sound, and expression, and in relationship to other performers.

Programs were administered as a summer day camp for 2 hr a day, 5 days a week, for 3 weeks in dance studios and public schools. Training included direct instruction and group activities, with a public performance at the end of the training. Teachers were faculty from York University's Faculty of Fine Arts, and all teachers had a graduate degree in their respective arts domain plus previous experience teaching children. Volunteers assisted with the programs to ensure a 5:1 supervision ratio.

Before and after training (or a gap for the nontrained group), participants were tested on various cognitive measures. Tasks as-

[1] Calculated power was to find a within–between interaction in a repeated measures ANOVA for a medium effect size ($f = 0.25$; Cohen, 1969, p. 348), three groups, two measurements per group (pre and post), and a correlation among measures of 0.7. The required total sample size was 42. A medium effect size was selected based on previous studies of musical training and cognition studies in children (Sala & Gobet, 2017b). For a small effect size ($f = 0.1$), the required total sample size would be 237 for the same parameters and a correlation among measures of 0.7 (the minimum reliability of the measures used), or 150 for the same parameters and a correlation among measures of 0.81 (the average reliability of the measures used).

Table 1
Means (SDs) for Background Characteristics of Participants for the Three Groups

Variable	Music (n = 24)	Dance (n = 26)	Control (n = 25)
Age (years)	7.6 (1.2)	8.1 (1.1)	7.6 (1.0)
Gender (number of females)	13	19	12
SES (mother's education[a])	3.9 (1.0)	4.0 (.8)	4.25 (.6)
Nonverbal IQ (K-BIT matrices standard score)	114 (18)	111 (14)	109 (15)

Note. SES = socioeconomic status; K-BIT = Kaufman Brief Intelligence Test.
[a] Mother's education was measured on the following scale: 1 = no high school, 2 = high school diploma, 3 = some college, 4 = college diploma, 5 = graduate or professional degree.

sessed executive function (working memory, interference control, task switching), nonverbal intelligence, receptive vocabulary, and processing speed. Means and standard deviations for all tasks at each time point are presented in Table 2. Details of task materials, design, and instructions are in File C of the online supplemental materials. Supplemental files and the data set supporting the conclusions of this article are available at the Open Science Framework repository, https://osf.io/5gsjq/.

Analyses

Data preparation. On tasks that recorded response times, iterative trimming with a three-standard-deviation cutoff was used, by subject and by condition, to remove outliers. Some participants failed to properly complete all of the measures at each assessment session, which created missing cells for some tasks. In total, 14.7% of all values were missing or determined to be outliers. The reasons for missing values were failure to complete the task properly, programming or technical issues, and participant attrition. Based on these, we believe that data are missing at random, as missing values for any given variable were unrelated to those of other variables.

To enhance reliability and avoid bias from listwise deletion of participants with missing values, estimates for missing scores were calculated by multiple imputation. Imputation was conducted using the Markov Chain Monte Carlo method with 100 iterations, which increased the likelihood of convergence for the estimates. Twenty imputations were conducted to enhance reliability, which enabled power falloff of less than 1%. Multiple imputation preserves the characteristics of the original data set, helps produce unbiased parameter estimates by accounting for the uncertainty in missing values (Schafer, 1999) and preventing a loss of power (Graham, Olchowski, & Gilreath, 2007), and is suitable for the current study given the obtained sample size and that less than 20% of values were missing (Graham, 2009). A pattern frequencies calculation showed that a pattern in which no missing values were present was the most prevalent, indicating that the number of missing values was not so large that imputation would bias data.

Difference scores for change across time were calculated for each measure by subtracting each participant's second testing session data from the first. Difference scores for tasks (with multiple experimental conditions) were calculated by subtracting one condition one from another. Specifically, incongruent scores were subtracted from congruent for interference control, and switch from nonswitch for task switching (Table 3).

Difference scores are appropriate because the cognitive tasks used have high reliability (see Table 4). Change difference scores are more appropriate than separate scores at each time point because the dependent variable of interest is a Time × Treatment interaction (Dimitrov & Rumrill, 2003; Edwards, 2001; Rogosa & Willett, 1983). Task difference scores are appropriate because the individual experimental condition met

Table 2
Mean (SD) Change in Performance for Each Cognitive Task and Group

Construct	Measure	Task	Music (n = 24)		Dance (n = 26)		Control (n = 25)	
			Pre	Post	Pre	Post	Pre	Post
Receptive vocabulary	Verbal ability	PPVT	112 (10.4)	117 (14.3)	111 (13.2)	112 (11.0)	109 (12.4)	110 (11.1)
Nonverbal intelligence	Visuospatial ability	K-BIT matrices	108 (18.1)	113 (21.2)	111 (14.0)	119 (10.7)	105 (13.9)	109 (16.6)
Short-term memory	Auditory span	Digit Span Forward	9.0 (1.9)	9.9 (2.1)	9.3 (1.8)	9.9 (1.8)	8.7 (2.6)	9.0 (2.4)
Working memory	Auditory span	Digit Span Backward	6.0 (1.4)	6.5 (1.8)	6.5 (1.7)	6.3 (1.7)	5.3 (2.2)	5.3 (2.6)
	Visuospatial span	Self-Ordered Pointing Task	4.3 (1.0)	4.2 (.9)	4.6 (.6)	4.2 (.8)	4.0 (.9)	4.1 (.6)
Inhibition/interference control	Response Inhibition	Flanker	81.9 (75.8)	60.9 (64.7)	51.3 (64.4)	72.5 (70.7)	28 (35)	22 (39)
	Semantic interference	Stroop	112 (78.1)	95.7 (40.2)	109 (79)	110 (62.6)	133 (76)	128 (59.8)
Task switching: Global switch cost	Unpredictable switching	Color–Shape	818 (464)	574 (240)	750 (439)	505 (336)	729 (359)	656 (407)
	Predictable switching	Quantity-Identity	1032 (338)	661 (263)	832 (237)	626 (240)	889 (315)	791 (354)
Task switching: Local switch cost	Unpredictable switching	Color–Shape	453 (688)	116 (363)	250 (611)	183 (430)	235 (523)	91 (510)
	Predictable switching	Quantity-Identity	329 (553)	363 (384)	213 (366)	254 (348)	241 (486)	229 (550)
Processing speed[a]	Psychomotor speed[b]	Box Completion	53.5 (13.5)	45.8 (10.8)	42.2 (13.3)	36.7 (11.1)	49.2 (14.8)	51.2 (17.2)
	Perceptual speed[b]	Symbol Copy[c]	53.6 (13.1)	58.5 (15.3)	62.2 (18.5)	67.2 (20.7)	54.8 (17.7)	60.3 (18.6)
	Perceptual speed	Digit Symbol Substitution	29.9 (10.5)	33.8 (14.0)	36.6 (12.7)	39.4 (12.8)	34.4 (10.9)	37.9 (11.3)

Note. PPVT = Peabody Picture Vocabulary Test; K-BIT = Kaufman Brief Intelligence Test.
[a] Tasks are classified using Salthouse's (1993) concept of processing speed, and its subdivisions into psychomotor and perceptual speed. [b] Measures of psychomotor speed measures involve perception of presented stimuli followed by a simple motor response, for example, rapidly drawing lines in designated locations on the box completion task or rapidly copying symbol stimuli on the symbol copy task. Perceptual-comparison measures involve an additional component for the comparison of two or more stimuli, for example, the digit symbol substitution task, in which digit stimuli must be compared to a set of digits and symbols and the corresponding symbol recorded. [c] Symbol copy has been classified as a psychomotor task in adults but as a perceptual speed task for children, as it also recruits working memory (Cepeda, Blackwell, & Munakata, 2013).

Table 3
Effect Size (Cohen's d) and Bayes Factor ($BF_{Inclusion}$) for Cognitive Measures

Construct	Measure	Task	Effect size (*d*) Music	Effect size (*d*) Dance	$BF_{inclusion}$
Receptive vocabulary	Verbal ability	PPVT	.55	.15	.778
Nonverbal intelligence	Visuospatial ability	K-BIT matrices	.11	.31	.331
Short-term memory	Auditory span	Digit Span Forward	.30	.12	.216
Working memory	Auditory span	Digit Span Backward	.37	.10	.138
	Visuospatial span	Self-Ordered Pointing Task	.16	.44	.004
Inhibition/interference control	Response inhibition	Flanker	.33	.17	.006
	Semantic interference	Stroop	.46	.24	.007
Task switching: Global switch cost	Unpredictable switching	Color–Shape	.77	.23	.033
	Predictable switching	Quantity-Identity	.22	.05	1.964
Task switching: Local switch cost	Unpredictable switching	Color–Shape	.77	.36	.265
	Predictable switching	Quantity-Identity	.57	.23	.031
Processing speed	Psychomotor speed	Box Completion	.73	.59	.757
	Perceptual speed	Symbol Copy	.11	.05	.243
	Perceptual speed	Digit Symbol Substitution	.30	.12	.213

Note. PPVT = Peabody Picture Vocabulary Test; K-BIT = Kaufman Brief Intelligence Test.

the assumptions of each task (e.g., a congruency difference score demonstrated a significant congruency effect rather than masking differences on speeded processing) and had a comparable reliability to that of each condition measured separately.

Null hypothesis significance testing. One-way ANOVAs to compare training groups (music, dance, or control) on difference scores were conducted on the multiply imputed data sets and pooled for each measure (refer to File D of the online supplemental materials for details of pooling procedure). To verify results, mixed ANOVAs were also calculated with time as a factor (using pre and post scores). The Time × Treatment interaction had exactly the same p value as the one-way ANOVAs with difference scores (post scores subtracted from pre scores) for all tasks.

Because multiple tests were used, it is possible that there may have been a Type I error. A Bonferroni correction was used to adjust the alpha level across all 14 tests, $p_{adjusted} = 0.00357$. A Bonferroni correction is not relevant if we were interested in separate effects of training for each task (and its underlying construct), although it is relevant for the general null hypothesis of an effect of our independent variable (music or dance training) across all dependent measures.

Estimation and Bayesian analyses. To overcome limitations with null hypothesis significance testing, significance testing was supplemented with estimation techniques and Bayesian analyses. Bayes factors were interpreted using a cutoff of $BF < 0.33$ as evidence for no difference between the groups (Jarosz & Wiley, 2014), that is, in favor of the null hypothesis. A $BF > 3$ was interpreted as evidence for a "substantial" difference (with different levels of strength depending on magnitude).

Estimation techniques consisted of effect sizes[2] and confidence intervals to describe the magnitude and precision of findings (Cumming, 2012, 2013, 2014; Nickerson, 2000). Reporting effect sizes and confidence intervals has been strongly recommended, even for nonsignificant effects, as these estimation techniques are more reliable and easier to interpret than significance testing (Cumming & Finch, 2005; Kline, 2013). Because visually presenting pre and post scores biases interpretation as a result of a correlation between the measurements, confidence interval graphs were calculated using difference scores for each group (Cumming & Finch, 2005). Graphs were designed using the ESCI software (Exploratory Software for Confidence Intervals; Cumming, 2013) for repeated measures designs. When interpreting graphs, a confidence interval with a mean difference that does not encompass zero indicates a significant change between pre- and posttesting.

Results

Task Switching

For the quantity-identity task, a measure of predictable task switching, the results show statistically significant changes in global switch cost for the experimental groups compared with the control, $F(2, 72) = 4.84$, $p = .031$, $BF_{inclusion} = 1.964$. The Bayes Factor indicated inconclusive evidence; hence, even though the p value was significant, evidence does not exist to support a meaningful interaction. Further, after accounting for the adjusted p value, the result is no longer significant.

The range of sample mean differences showed faster RTs for the music and dance groups on global switch cost for the quantity-identity task (see Figure 1). In contrast, the range for the control group mean change varied from a decrease to an increase in RTs, indicating that some participants got worse. Moreover, the entire interval of response times for the music group showed no overlap with the control group. There was an overlap between groups on global switch cost for the color–shape task and on local switch cost for both tasks.

On the color–shape task, the results were not statistically significant for global switch cost, $F(2, 70.1) = 0.88$, $p = .42$, $BF_{inclusion} = 0.033$. For local switch cost, no significant changes were found on the quantity-identity task, all $F\text{s} \leq 0.612$, $p\text{s} > 0.250$, $BF_{inclusion} = 0.031$, or the color–shape task, $F(2, 70.1) = 2.14$, $p = .126$, $BF_{inclusion} = 0.265$.

Processing Speed

On processing speed measures, no significant result was found on the box completion task, $F(2, 70) = 2.61$, $p = .081$, and Bayesian analyses were inconclusive, $BF_{inclusion} = 0.757$. No significant effects were found in the number of items completed on the symbol copy, $F(2, 70.1) = 0.038$, $p = .96$, $BF_{inclusion} = 0.243$, or symbol coding tasks, $F(2, 70.1) = 0.143$, $p = .87$, $BF_{inclusion} = 0.213$. Confidence intervals on the mean difference show that the groups overlapped almost completely (see Figure 2).

[2] Effect sizes were calculated by comparing each treatment group with the untrained control group (Sedgwick, 2015a, 2015b).

Table 4
Published Psychometrics for Cognitive Measures

Construct	Measure	Task	Internal consistency (split-half reliability)	Test–retest reliability (stability)	Reference
Receptive vocabulary	Verbal ability	PPVT	.94	.93	Dunn, Dunn, & Lenhard (2015)
Nonverbal intelligence	Visuospatial ability	K-BIT matrices	.88	.83	Kaufman & Kaufman (2004)
Short-term memory	Auditory span	Digit Span Forward	.83[a]	.72	Williams, Weiss, & Rolfhus (2003)
Working memory	Auditory span	Digit Span Backward	.80	.67	Williams et al. (2003)
	Visuospatial span	SOPT	.88[b]	.71[f]	Cragg & Nation (2007); Willoughby & Blair (2011)
Inhibition/interference control	Response inhibition	Flanker	.75[c]	.92[g]	Zelazo et al. (2013)
	Semantic interference	Stroop	.87		Friedman et al. (2006); Xu et al. (2013)
Task switching: Global switch cost	Unpredictable switching	Color–Shape	.88[c]		Paap & Sawi (2014)
	Predictable switching	Quantity-Identity	.83		Xu et al. (2013)
Task switching: Local switch cost	Unpredictable switching	Color–Shape	.78		Friedman et al. (2006)
	Predictable switching	Quantity-Identity	.77[d]		Xu et al. (2013)
Processing speed	Psychomotor speed	Box Completion	.97[c]	.78[h]	Fristoe, Salthouse, & Woodard (1997); Salthouse (1994)
	Perceptual speed	Symbol Copy	.95[c]	.93	Salthouse & Meinz (1995); Williams et al. (2003)
	Perceptual speed	Digit Symbol Substitution	.85[e]	.97	Conway, Cowan, Bunting, Therriault, & Minkoff (2002); Salthouse (1994)

Note. PPVT = Peabody Picture Vocabulary Test; K-BIT = Kaufman Brief Intelligence Test; SOPT = Self-Ordered Pointing Task.
[a] Fisher's *z* transformation. [b] Cronbach's alpha (α). [c] Spearman-Brown Prophecy correlation. [d] Based on Number–Letter task, and Category-Switch task, both explicit cue paradigms. [e] A similar version of the task (symbol coding; Salthouse, 1994). [f] A version of the task based on the original (Cragg & Nation, 2007). [g] Test–retest intraclass correlation coefficients. [h] Alternate forms (equivalence testing).

Working Memory

There were no significant changes in either of the trained groups' working memory measures, as measured by the digit span forward task, $F(2, 70.1) = 0.611$, $p = .55$, $BF_{inclusion} = 0.216$, the digit span backward task, $F(2, 69.6) = 1.39$, $p = .26$, $BF_{inclusion} = 0.138$, or the self-ordered pointing task, $F(2, 67.5) = 1.69$, $p = .193$, $BF_{inclusion} = 0.004$ (see Figure 3).

Interference Control

The flanker task had significant differences between groups at baseline ($p = .020$), so posttest scores were analyzed after entering pretest scores as a covariate. A significant interaction was found between group and time, $F(1, 73) = 6.42$, $p = .013$, but this result was not supported by Bayesian analyses, $BF_{inclusion} = 0.137$, indicating that the finding is not robust. No effect was found on the Stroop task, $F(2, 70) = 0.26$, $p > .250$, $BF_{inclusion} = 0.007$. As demonstrated in the confidence interval graphs, the range of mean differences for all groups was centered around zero (see Figure 4).

Nonverbal Intelligence and Receptive Vocabulary

On receptive vocabulary, as measured by the Peabody Picture Vocabulary Test (PPVT; Dunn, Dunn, & Lenhard, 2015), there was no significant difference on the vocabulary score, $F(2, 69.9) = 2.42$, $p = .096$, $BF_{inclusion} = 0.778$. The 95% confidence intervals indicate that the range of values for the mean from pre to post on the PPVT shows a considerably larger increase in task performance for the music group compared with the dance and the control groups (see Figure 5). On nonverbal intelligence, as measured by the K-BIT matrices, there was no evidence for an effect, $F(2, 70) = 0.64$, $p > .250$, $BF_{inclusion} = 0.331$.

Discussion

A central question in psychological science is determining whether training can produce cognitive benefits. The gold standard in answering this is evaluation of change using experimental trials. Because of minimal experimental studies until now, research has not been able to definitively conclude the reliability of a documented cognitive advantage in musicians. The current randomized controlled trial found no changes on cognitive performance after a short period of music training compared with dance training or a nontrained group. The results support increasing existing experimental evidence on the lack of causal effects from short-term musical training on cognition. The findings situate effects of music within evidence from the training literature that far transfer from training to cognition is rare.

The majority of existing music research has used nonexperimental designs (correlational, longitudinal, or quasi-experimental) and found a musician advantage on cognition. Conversely, the small number of experimental studies suggest few to no effects, especially with strong methodological designs (Sala & Gobet, 2017b). Although nonexperimental studies have been helpful in exploring the possible range of cognitive benefits, the field has reached a point at which controlled experiments such as the current study are useful in clarifying the discrepancy between nonexperimental and experimental results.

We tested the possibility of a musician advantage in two ways: whether effects of training were general (i.e., existed across cognitive abilities) and unique to music (in comparison with dance training and no training). The large task battery tested changes in a range of cognitive abilities following training. No experimental support was found on any of the abilities measured (working memory, interference control, task switching, processing speed, receptive vocabulary, or nonverbal intelligence) following training. The lack of improvement across cognitive measures also rules out the previous theoretical propositions of core cognitive abilities (executive functions, processing speed) or core training mechanisms (multimodal coordination and rhythm entrainment) as mediators for a cognitive benefit. No significant differences were observed any of the groups measured, indicating no unique benefits from short-term musical training.

Different aspects of the research design were controlled to parse training effects from alternative factors that influence cognition. Measuring individuals before and after training allowed calculation of the absolute magnitude of training effects compared with baseline performance. The use of a passive control group isolated causal effects of

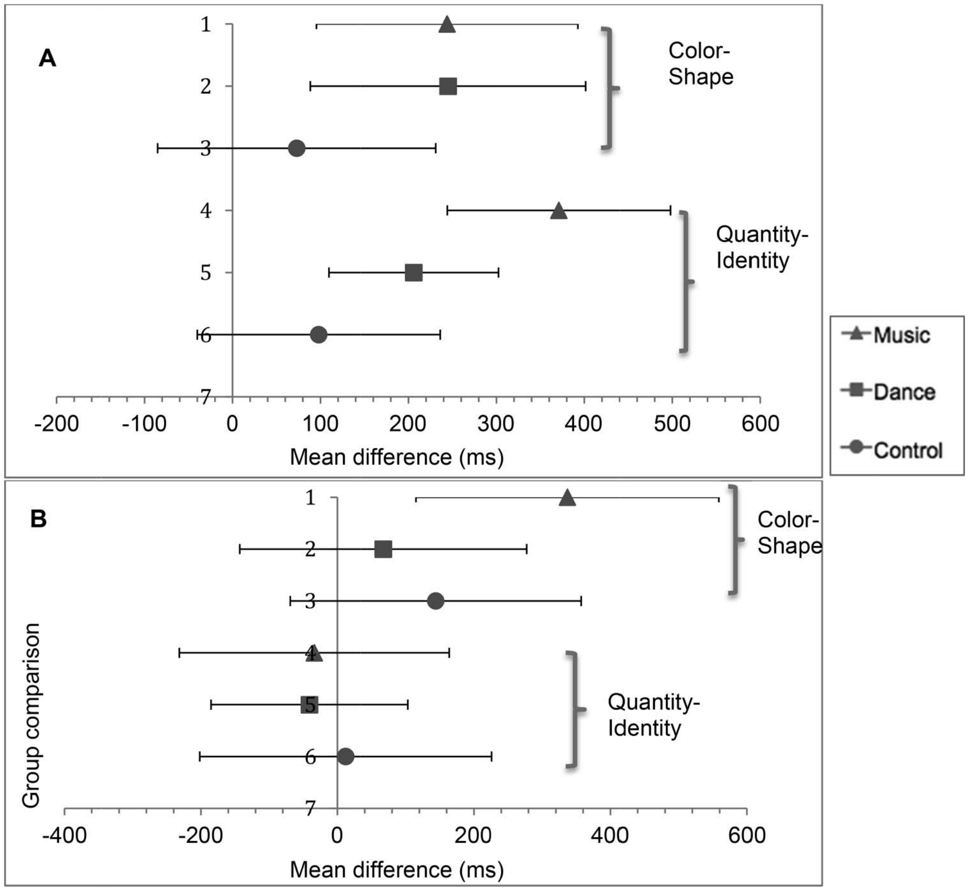

Figure 1. Mean change from pre- to posttraining for each group, with a 95% confidence interval on the mean difference scores for task switching reaction time on (A) global and (B) local switch cost. Decreases indicate an improvement in performance.

training from normal development (Sedgwick, 2015a, 2015b). Using two training groups with matched features served as active controls to confirm whether the overlapping features have similar effects (Moreau & Conway, 2013). Self-selection into training and any background characteristics associated with individuals who are usually drawn to music or dance were ruled out by using a sample without previous arts training and randomly assigning them to the type of training.

Strengths and Limitations of the Current Study

Groups were similar on all dependent variables (except one) and prognostic factors (IQ, socioeconomic status, age) at baseline; hence, any changes can be attributed to training rather than preexisting differences between groups. A limitation is that the passive control group was not randomly assigned, and nonrandomized trials risk allocation bias from unmatched groups because of the inability to control the balance of prognostic factors between the treatment groups (Li, 2014). However, the groups were equivalent at baseline on prognostic factors and can statistically be treated as random.

The decision to not randomly assign individuals to a passive control group provided an ethical advantage—it would have been unfair to provide some recruited individuals but not others with a free arts program. Even if it were done, the motivation, preferences for a certain intervention, and experience of receiving an intervention between active control and passive controls at posttesting would not have been equal. Using a nonrandomized trial also enabled use of a community-based trial, whereby complete communities within the target population were targeted in the study. The community approach enhances external validity because the study results can be generalized to the population that the sample is meant to represent. Conversely, the strict inclusion criteria of randomized trials may limit recruitment to participants who are not as representative of the population, as it involves only participants that are willing to be randomized (even to a passive group). A further benefit is that our passive control group was blinded, as they did not know they were in an intervention study, and the active controls also did not know the expected benefits for their group versus the other program.

Although random assignment and repeated measurements help rule out third-factor explanations for previously demonstrated effects from nonexperimental evidence, there are several differences in training between experimental and nonexperimental trials. It is conceivable that benefits from training exist with other training parameters (e.g., type or amount of training). The main difference is that most nonexperimental studies test experts with many years of training. A longer training duration might produce greater benefits, but benefits are often largest early in learning and may even reach an upper limit (Barrett, Ashley, Strait, & Kraus, 2013). Future longitudinal studies could bridge this gap by tracking the trajectory of training-related change, although longer programs face issues of participant dropout and are less feasible to implement. The chosen duration of several weeks is typical of training

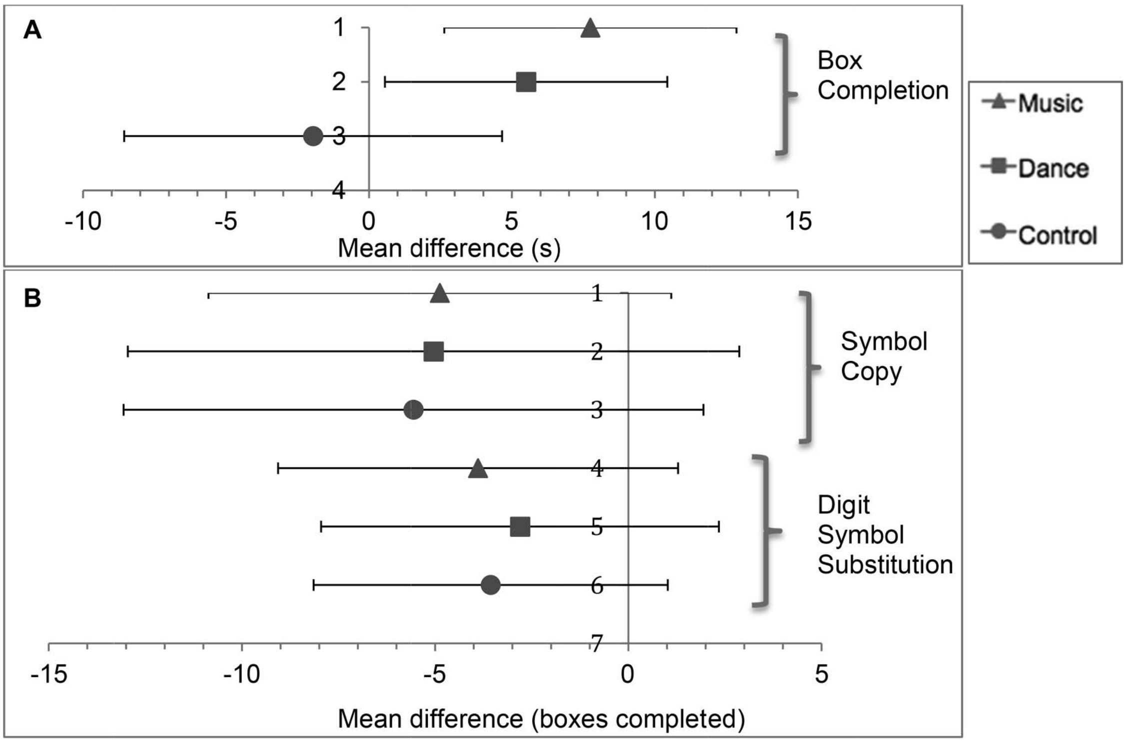

Figure 2. Mean change from pre- to posttraining for each group, with a 95% confidence interval for (A) processing speed reaction time and (B) number of boxes completed. Decreases in reaction time (A) indicate an improvement in performance, and increases in the number of boxes (B) indicate an improvement.

studies (Slagter et al., 2011), and cognitive benefits have been found even with two sessions (Kimura & Hozumi, 2012).

There is notable heterogeneity in what was actually trained in published research, which makes it difficult to compare across studies. Nevertheless, several elements that are core to learning music and tend to emerge across studies. We focus on these elements (Ontario Ministry of Education, 2009, p. 18) and hope that our operational definitions for music and dance provide a foundation for future investigations. Prospective research on the locus of training effects can test the extent of similarity between music and dance in the elements trained and at a cognitive level to identify the "active ingredients" for each.

Differences in tasks or conceptualizing cognitive constructs could also explain the inconsistency between our results and past studies. Executive functions, in particular, are difficult to measure and classify (Jurado & Rosselli, 2007). Results vary across measures of a construct and even on the same measure (Bergman Nutley, Darki, & Klingberg, 2014; George & Coch, 2011; cf. Janus

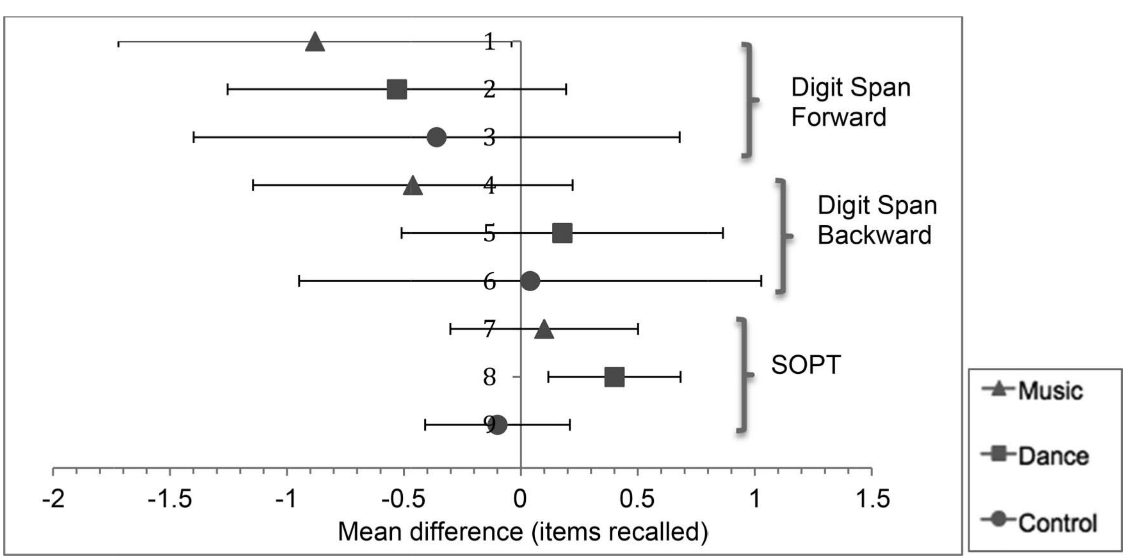

Figure 3. Mean change from pre- to posttraining for each group, with a 95% confidence interval for working memory span. Increases indicate an improvement in performance.

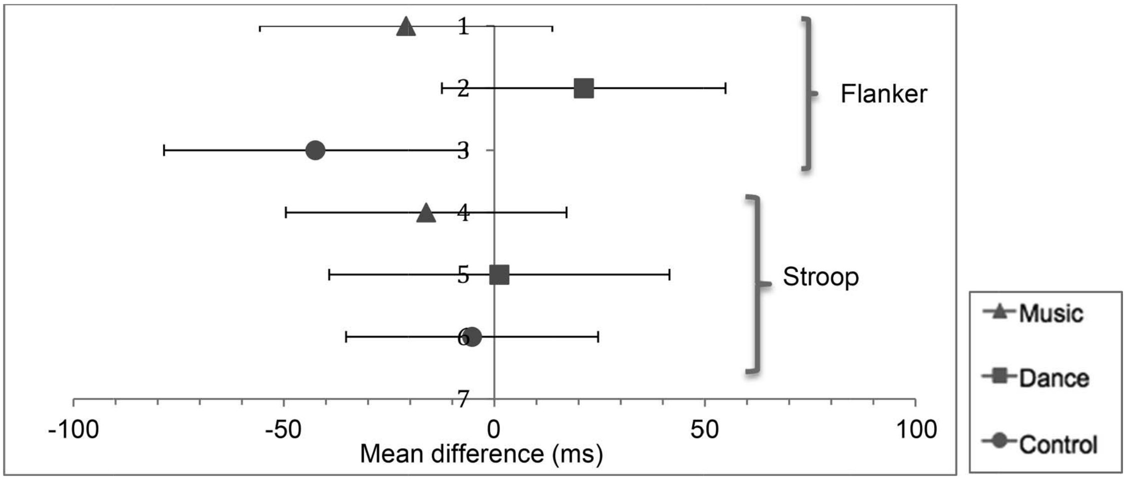

Figure 4. Mean change from pre- to posttraining for each group with a 95% confidence interval for interference control reaction time. Decreases indicate an improvement in performance.

et al., 2016). Future studies using multiple tasks per measure are desirable and have shown a coherent effect of musical training across multiple measures of the same construct (D'Souza et al., in press; Moradzadeh et al., 2015).

The ability to detect changes in executive function was limited to the sample of individuals used. Children with low executive function performance or low socioeconomic status benefit the most from cognitive interventions (Diamond, 2012). Because our sample was from middle- to upper-class neighborhoods, individuals from less privileged backgrounds may have more room for improvement. Follow-up research can look into interactions of training with background variables.

The timing of measurement may have influenced observed effects. Participants were measured 1 to 2 weeks after training ended, although in a few cases, follow-up was 3 weeks later because of practical constraints. Results may have underestimated training effects and missed any short-term benefits, although a follow-up analysis accounting for time between training and posttesting session failed to find any change in the obtained results. The reliability of measures should also be considered (refer supplemental material for validity of measures), particularly the short-term reliability of measures given the brief duration of the study and possibility of practice effects. The use of a passive control group with the same short-term window helps isolate practice effects from additional effects as a result of training.

Insights Into Cognitive Transfer

The current findings offer exploratory insights on the cognitive impact of dance, a skill form that has been largely neglected in the cognitive training literature. Previous training research and public opinions have centered around music cognition, sometimes at the expense of other art forms. Follow-up studies can isolate and test the putative effects of music by comparing it with other activities. Past demonstrations have assessed activities that have minimal overlap in training elements with music, such as drama, natural science, and visual arts (Moreno et al., 2011; Roden, Grube, et al., 2014; Roden, Könen, et al., 2014; Schellenberg, 2004). The current study attempts a complementary aim of comparing music with a similar activity. Although it is valuable to use completely different training activities, it is equally theoretically useful to use similar ones.

There was a significant improvement on task switching for both trained groups, although it was found on one task (predictable

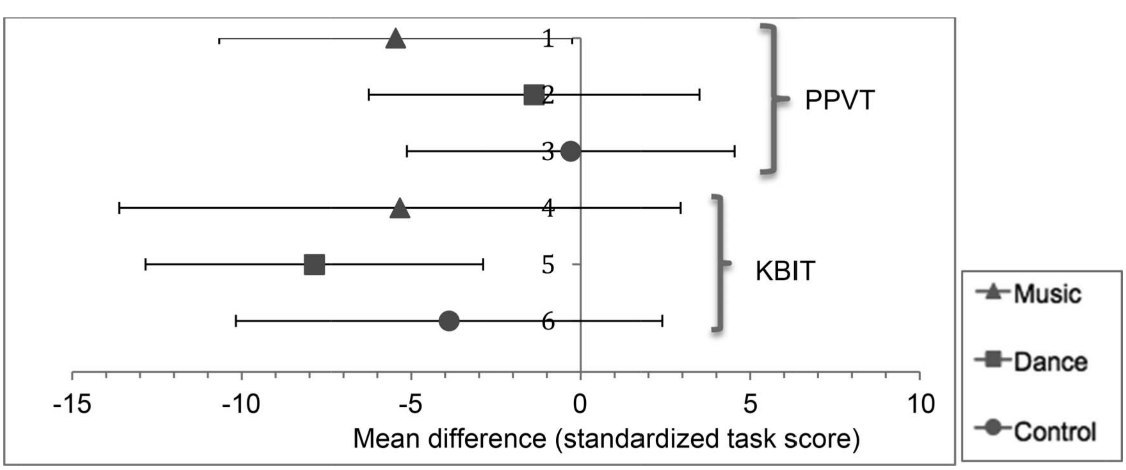

Figure 5. Mean change from pre to post training for each group with a 95% confidence interval for intelligence. PPVT = Peabody Picture Vocabulary Test; K-BIT = Kaufman Brief Intelligence Test.

switching) and on one type of task switching (global switch cost). However, strong causal conclusions are not merited because of the equivalence of results for both experimental groups and the lack of a randomly assigned passive control group. Second, the result may have been the result of a Type I error because the effect was not robust to better statistical analyses—it was no longer significant after accounting for multiplicity and lacked support from Bayesian analyses. Moreover, a similar effect was not found on the other task (unpredictable switching) for the same type of task switching (global switch cost), nor on both tasks on another type of task switching (local switch cost).

Although the results do not provide adequate quantitative support for any training effects, it is plausible that the observed benefit on predictable task switching may be more than a statistical artifact, because there is meaningful overlap between the training content in music and dance and the tested ability of predictable task switching. Theories of transfer and evidence from skill learning studies show that improvements are contingent on an overlap between training paradigms and tested cognitive abilities (Barnett & Ceci, 2002; Carey et al., 2015; Diamond, 2012; Green & Bavelier, 2008; Lövdén et al., 2010; Slagter et al., 2011).

The main overlap between both training forms is multimodal coordination and rhythm entrainment. Rhythm entrainment is a core feature of both music and dance and has been explicitly proposed as the mechanism that supports development of executive functions for training effects from music and dance (Miendlarzewska & Trost, 2014). Processes that comprise rhythm entrainment, including coordination of movement to temporal patterns, bear conceptual resemblance to predictable task switching. Rhythm entrainment involves learning rhythm (patterns in timing and structure despite changes in sound; Rohrmeier & Rebuschat, 2012; Tillmann, 2005; Tillmann & McAdams, 2004), then consistently timing motor responses to the rhythm (Baer, Thibodeau, Gralnick, Li, & Penhune, 2013; Chen, Penhune, & Zatorre, 2008; Grahn & Brett, 2007; Slater, Tierney, & Kraus, 2013). Similarly, predictable task switching involves learning a fixed pattern of responses, in this case, switching between tasks in an alternate manner, and then timing responses to that pattern. It is plausible that the training of synchronizing motor responses to a set pattern in music and dance generalized to synchronizing motor responses to a fixed task-change rhythm, but this conclusion is purely speculative without further research.

The lack of training benefits fit with the small size and scope of transfer effects in the training literature, in which training-induced change, particularly far transfer, is the exception rather than the norm (Green & Bavelier, 2008; Noack et al., 2009; Slagter et al., 2011). Similarly, the possibility of enhancing intelligence through remediation and training has been questioned by researchers (e.g., Chooi & Thompson, 2012). In contrast, lay perspectives on the malleability of intellectual ability and general cognitive performance tend to be overwhelmingly hopeful and are partly misguided by miscommunication of research findings in the popular press (Mehr, 2015). The narrow scope of transfer of training forms, particularly short-term training, suggests cautiousness when making recommendations prescribing training.

The topic of improving cognition is increasingly ubiquitous. Positive findings on transfer from the arts to cognition offer promising applications and have been used to encourage evidence-based arguments in favor of arts education for children (Catterall, 2002; cf. Winner & Cooper, 2000). If the value of a training domain is based on abilities that are not directly related to what was learned during acquisition (as may be the case with cognition), a lack of consistent empirical support can make training domains appear inferior. Future research could test transfer on other abilities that are more relevant to arts training, including noncognitive abilities such as mood and creativity (Hallam, 2010). Further, beyond transfer to mental performance (both cognitive and noncognitive), we echo previous researchers that the intrinsic value of music and dance should remain central to the justification of arts education in school curriculums (Collins, 2014; Gazzaniga, 2008; Gill & Rickard, 2012).

References

Aagten-Murphy, D., Cappagli, G., & Burr, D. (2014). Musical training generalises across modalities and reveals efficient and adaptive mechanisms for reproducing temporal intervals. *Acta Psychologica, 147,* 25–33. http://dx.doi.org/10.1016/j.actpsy.2013.10.007

Baer, L. H., Thibodeau, J. L. N., Gralnick, T. M., Li, K. Z. H., & Penhune, V. B. (2013). The role of musical training in emergent and event-based timing. *Frontiers in Human Neuroscience, 7,* 191. http://dx.doi.org/10.3389/fnhum.2013.00191

Barnett, S. M., & Ceci, S. J. (2002). When and where do we apply what we learn? A taxonomy for far transfer. *Psychological Bulletin, 128,* 612–637. http://dx.doi.org/10.1037/0033-2909.128.4.612

Barrett, K. C., Ashley, R., Strait, D. L., & Kraus, N. (2013). Art and science: How musical training shapes the brain. *Frontiers in Psychology, 4,* 713. http://dx.doi.org/10.3389/fpsyg.2013.00713

Bergman Nutley, S., Darki, F., & Klingberg, T. (2014). Music practice is associated with development of working memory during childhood and adolescence. *Frontiers in Human Neuroscience, 7,* 926. http://dx.doi.org/10.3389/fnhum.2013.00926

Bläsing, B., Calvo-Merino, B., Cross, E. S., Jola, C., Honisch, J., & Stevens, C. J. (2012). Neurocognitive control in dance perception and performance. *Acta Psychologica, 139,* 300–308. http://dx.doi.org/10.1016/j.actpsy.2011.12.005

Bugos, J. A. (2010). The benefits of music instruction on processing speed, verbal fluency, and cognitive control in aging. *Music Education Research International, 4,* 1–9.

Bugos, J., & Mostafa, W. (2011). Musical training enhances information processing speed. *Bulletin of the Council for Research in Music Education, 187,* 7–18.

Bunge, S. A., Dudukovic, N. M., Thomason, M. E., Vaidya, C. J., & Gabrieli, J. D. (2002). Immature frontal lobe contributions to cognitive control in children: Evidence from fMRI. *Neuron, 33,* 301–311. http://dx.doi.org/10.1016/S0896-6273(01)00583-9

Carey, D., Rosen, S., Krishnan, S., Pearce, M. T., Shepherd, A., Aydelott, J., & Dick, F. (2015). Generality and specificity in the effects of musical expertise on perception and cognition. *Cognition, 137,* 81–105. http://dx.doi.org/10.1016/j.cognition.2014.12.005

Catterall, J. S. (2002). The arts and the transfer of learning. In R. Deasy (Ed.), *Critical links: Learning in the arts and student academic and social development* (pp. 151–157). Washington, DC: Arts Education Partnership.

Cepeda, N. J., Blackwell, K. A., & Munakata, Y. (2013). Speed isn't everything: Complex processing speed measures mask individual differences and developmental changes in executive control. *Developmental Science, 16,* 269–286. http://dx.doi.org/10.1111/desc.12024

Cepeda, N. J., Cepeda, M. L., & Kramer, A. F. (2000). Task switching and attention deficit hyperactivity disorder. *Journal of Abnormal Child Psychology, 28,* 213–226. http://dx.doi.org/10.1023/A:1005143419092

Chen, J. L., Penhune, V. B., & Zatorre, R. J. (2008). Moving on time: Brain network for auditory-motor synchronization is modulated by rhythm complexity and musical training. *Journal of Cognitive Neuroscience, 20,* 226–239. http://dx.doi.org/10.1162/jocn.2008.20018

Cohen, J. (1969). *Statistical power analysis for the behavioural sciences*. New York, NY: Academic Press.

Collins, A. (2014). Neuroscience, music education and the pre-service primary (elementary) generalist teacher. *International Journal of Education and the Arts, 15,* 5. Retrieved May 1, 2018 from http://www.ijea.org/v15n5/

Conway, A. R., Cowan, N., Bunting, M. F., Therriault, D. J., & Minkoff, S. R. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30,* 163–183. http://dx.doi.org/10.1016/S0160-2896(01)00096-4

Coubard, O. A., Duretz, S., Lefebvre, V., Lapalus, P., & Ferrufino, L. (2011). Practice of contemporary dance improves cognitive flexibility in aging. *Frontiers in Aging Neuroscience, 3,* 13. http://dx.doi.org/10.3389/fnagi.2011.00013

Cox, H. A., & Stephens, L. J. (2006). The effect of music participation on mathematical achievement and overall academic achievement of high school students. *International Journal of Mathematical Education in Science and Technology, 37,* 757–763. http://dx.doi.org/10.1080/00207390500137811

Chooi, W.-T., & Thompson, L. A. (2012). Working memory training does not improve intelligence in healthy young adults. *Intelligence, 40,* 531–542. http://dx.doi.org/10.1016/j.intell.2012.07.004

Cragg, L., & Nation, K. (2007). Self-ordered pointing as a test of working memory in typically developing children. *Memory, 15,* 526–535. http://dx.doi.org/10.1080/09658210701390750

Črnčec, R., Wilson, S. J., & Prior, M. (2006). The cognitive and academic benefits of music to children: Facts and fiction. *Educational Psychology, 26,* 579–594. http://dx.doi.org/10.1080/01443410500342542

Cumming, G. (2012). *Understanding the new statistics: Effect sizes, confidence intervals, and meta-analysis*. New York, NY: Routledge.

Cumming, G. (2013). *The new statistics: Estimation for better research*. Retrieved from http://www.thenewstatistics.com

Cumming, G. (2014). The new statistics: Why and how. *Psychological Science, 25,* 7–29. http://dx.doi.org/10.1177/0956797613504966

Cumming, G., & Finch, S. (2005). Inference by eye: Confidence intervals and how to read pictures of data. *American Psychologist, 60,* 170–180. http://dx.doi.org/10.1037/0003-066X.60.2.170

Degé, F., Kubicek, C., & Schwarzer, G. (2011). Music lessons and intelligence: A relation mediated by executive functions. *Music Perception, 29,* 195–201. http://dx.doi.org/10.1525/mp.2011.29.2.195

Degé, F., Wehrum, S., Stark, R., & Schwarzer, G. (2011). The influence of two years of school music training in secondary school on visual and auditory memory. *European Journal of Developmental Psychology, 8,* 608–623. http://dx.doi.org/10.1080/17405629.2011.590668

Degé, F., Wehrum, S., Stark, R., & Schwarzer, G. (2014). Music lessons and academic self-concept in 12- to 14-year-old children. *Musicae Scientiae, 18,* 203–215. http://dx.doi.org/10.1177/1029864914523283

Dhami, P., Moreno, S., & DeSouza, J. F. (2015). New framework for rehabilitation-fusion of cognitive and physical rehabilitation: The hope for dancing. *Frontiers in Psychology, 5,* 1478. http://dx.doi.org/10.3389/fpsyg.2014.01478

Diamond, A. (2012). Activities and programs that improve children's executive functions. *Current Directions in Psychological Science, 21,* 335–341. http://dx.doi.org/10.1177/0963721412453722

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64,* 135–168. http://dx.doi.org/10.1146/annurev-psych-113011-143750

Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333,* 959–964. http://dx.doi.org/10.1126/science.1204529

Dimitrov, D. M., & Rumrill, P. D., Jr. (2003). Pretest-posttest designs and measurement of change. *Work: Journal of Prevention, Assessment & Rehabilitation, 20,* 159–165.

Dumont, E., Syurina, E. V., Feron, F. J. M., & van Hooren, S. (2017). Music interventions and child development: A critical review and future directions. *Frontiers in Psychology, 8,* 1694. http://dx.doi.org/10.3389/fpsyg.2017.01694

D'Souza, A. A., Moradzadeh, L., & Wiseheart, M. (in press). Musical training, bilingualism, and executive function: Working memory and inhibitory control. *Cognitive Research: Principles and Implications*.

D'Souza, A., & Wiseheart, M. (2018). *Cognitive effects of music and dance training in children* (ICPSR37080.v1) [Data set]. Ann Arbor, MI. Inter-University Consortium for Political and Social Research. http://dx.doi.org/10.3886/ICPSR37080.v1

Dunn, L. M., Dunn, D. M., & Lenhard, A. (2015). *Peabody picture vocabulary test: PPVT 4*. Bloomington, MN: Pearson Assessments.

Edwards, J. R. (2001). Ten difference score myths. *Organizational Research Methods, 4,* 265–287. http://dx.doi.org/10.1177/109442810143005

Fitzpatrick, K. R. (2006). The effect of instrumental music participation and socioeconomic status on Ohio fourth-, sixth-, and ninth-grade proficiency test performance. *Journal of Research in Music Education, 54,* 73–84. http://dx.doi.org/10.1177/002242940605400106

Foster, P. P. (2013). How does dancing promote brain reconditioning in the elderly? *Frontiers in Aging Neuroscience, 5,* 4. http://dx.doi.org/10.3389/fnagi.2013.00004

Friedman, N. P., Miyake, A., Corley, R. P., Young, S. E., Defries, J. C., & Hewitt, J. K. (2006). Not all executive functions are related to intelligence. *Psychological Science, 17,* 172–179. http://dx.doi.org/10.1111/j.1467-9280.2006.01681.x

Fristoe, N. M., Salthouse, T. A., & Woodard, J. L. (1997). Examination of age-related deficits on the Wisconsin Card Sorting Test. *Neuropsychology, 11,* 428–436. http://dx.doi.org/10.1037/0894-4105.11.3.428

Gazzaniga, M. (2008). Arts and cognition: Findings hint at relationships. In M. deLong & T. Wichmann (Eds.), *Learning, arts, and the brain: The Dana Consortium report on arts and cognition* (pp. v–viii). New York, NY: Dana Press.

George, E. M., & Coch, D. (2011). Music training and working memory: An ERP study. *Neuropsychologia, 49,* 1083–1094. http://dx.doi.org/10.1016/j.neuropsychologia.2011.02.001

Gill, A., & Rickard, N. S. (2012). Non-music benefits of school-based music training. In N. S. Rickard & K. McFerran (Eds.), *Lifelong engagement with music: Benefits for mental health and well-being*. New York, NY: Nova Science Publishers.

Gondola, J. C. (1987). The effects of a single bout of aerobic exercise on selected tests of creativity. *Journal of Social Behavior and Personality, 2,* 275–278.

Graham, J. W. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology, 60,* 549–576. http://dx.doi.org/10.1146/annurev.psych.58.110405.085530

Graham, J. W., Olchowski, A. E., & Gilreath, T. D. (2007). How many imputations are really needed? Some practical clarifications of multiple imputation theory. *Prevention Science, 8,* 206–213. http://dx.doi.org/10.1007/s11121-007-0070-9

Grahn, J. A., & Brett, M. (2007). Rhythm and beat perception in motor areas of the brain. *Journal of Cognitive Neuroscience, 19,* 893–906. http://dx.doi.org/10.1162/jocn.2007.19.5.893

Green, C. S., & Bavelier, D. (2008). Exercising your brain: A review of human brain plasticity and training-induced learning. *Psychology and Aging, 23,* 692–701. http://dx.doi.org/10.1037/a0014345

Hallam, S. (2010). The power of music: Its impact on the intellectual, social and personal development of children and young people. *International Journal of Music Education, 28,* 269–289. http://dx.doi.org/10.1177/0255761410370658

Hamacher, D., Hamacher, D., Rehfeld, K., Hökelmann, A., & Schega, L. (2015). The effect of a six-month dancing program on motor-cognitive dual-task performance in older adults. *Journal of Aging and Physical Activity, 23,* 647–652. http://dx.doi.org/10.1123/japa.2014-0067

Hanna-Pladdy, B., & MacKay, A. (2011). The relation between instrumental musical activity and cognitive aging. *Neuropsychology, 25,* 378–386. http://dx.doi.org/10.1037/a0021895

Hannon, E. E., & Trainor, L. J. (2007). Music acquisition: Effects of enculturation and formal training on development. *Trends in Cognitive Sciences, 11,* 466–472. http://dx.doi.org/10.1016/j.tics.2007.08.008

Hansen, M., Wallentin, M., & Vuust, P. (2013). Working memory and musical competence of musicians and non-musicians. *Psychology of Music, 41,* 779–793. http://dx.doi.org/10.1177/0305735612452186

Hargreaves, D. J., & Aksentijevic, A. (2011). Music, IQ, and the executive function. *British Journal of Psychology, 102,* 306–308. http://dx.doi.org/10.1111/j.2044-8295.2011.02029.x

Isaacs, T., & Trofimovich, P. (2011). Phonological memory, attention control, and musical ability: Effects of individual differences on rater judgments of second language speech. *Applied Psycholinguistics, 32,* 113–140. http://dx.doi.org/10.1017/S0142716410000317

Jäncke, L. (2009). Music drives brain plasticity. *F1000 Biology Reports, 1,* 78.

Janus, M., Lee, Y., Moreno, S., & Bialystok, E. (2016). Effects of short term music and second language training on executive control. *Journal of Experimental Child Psychology, 144,* 84–97. http://dx.doi.org/10.1016/j.jecp.2015.11.009

Jarosz, A. F., & Wiley, J. (2014). What are the odds? A practical guide to computing and reporting Bayes factors. *Journal of Problem Solving, 7,* 2–9. http://dx.doi.org/10.7771/1932-6246.1167

Joret, M.-E., Germeys, F., & Gidron, Y. (2017). Cognitive inhibitory control in children following early childhood music education. *Musicae Scientiae, 21,* 303–315. http://dx.doi.org/10.1177/1029864916655477

Jurado, M. B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychology Review, 17,* 213–233. http://dx.doi.org/10.1007/s11065-007-9040-z

Kaganovich, N., Kim, J., Herring, C., Schumaker, J., Macpherson, M., & Weber-Fox, C. (2013). Musicians show general enhancement of complex sound encoding and better inhibition of irrelevant auditory change in music: An ERP study. *European Journal of Neuroscience, 37,* 1295–1307. http://dx.doi.org/10.1111/ejn.12110

Kattenstroth, J.-C., Kalisch, T., Holt, S., Tegenthoff, M., & Dinse, H. R. (2013). Six months of dance intervention enhances postural, sensorimotor, and cognitive performance in elderly without affecting cardio-respiratory functions. *Frontiers in Aging Neuroscience, 5,* 5. http://dx.doi.org/10.3389/fnagi.2013.00005

Kattenstroth, J.-C., Kolankowska, I., Kalisch, T., & Dinse, H. R. (2010). Superior sensory, motor, and cognitive performance in elderly individuals with multi-year dancing activities. *Frontiers in Aging Neuroscience, 2,* 31.

Kaufman, A. S., & Kaufman, N. L. (2004). *Kaufman brief intelligence test* (2nd ed.). San Antonio, TX: Pearson Assessments.

Keinänen, M., Hetland, L., & Winner, E. (2000). Teaching cognitive skill through dance: Evidence for near but not far transfer. *Journal of Aesthetic Education, 34,* 295–306. http://dx.doi.org/10.2307/3333646

Kimura, K., & Hozumi, N. (2012). Investigating the acute effect of an aerobic dance exercise program on neuro-cognitive function in the elderly. *Psychology of Sport and Exercise, 13,* 623–629. http://dx.doi.org/10.1016/j.psychsport.2012.04.001

Kline, P. (2013). *Handbook of psychological testing* (2nd ed.). London, UK: Routledge.

Lee, Y., Lu, M., & Ko, H. (2007). Effects of skill training on working memory capacity. *Learning and Instruction, 17,* 336–344. http://dx.doi.org/10.1016/j.learninstruc.2007.02.010

Li, Z. (2014). Non-randomized trial: A tutorial. *Wiley StatsRef: Statistics Reference Online*. http://dx.doi.org/10.1002/9781118445112.stat07113

Loehr, J. D., Kourtis, D., Vesper, C., Sebanz, N., & Knoblich, G. (2013). Monitoring individual and joint action outcomes in duet music performance. *Journal of Cognitive Neuroscience, 25,* 1049–1061. http://dx.doi.org/10.1162/jocn_a_00388

Loehr, J. D., Large, E. W., & Palmer, C. (2011). Temporal coordination and adaptation to rate change in music performance. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 1292–1309. http://dx.doi.org/10.1037/a0023102

Lövdén, M., Bäckman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological Bulletin, 136,* 659–676. http://dx.doi.org/10.1037/a0020080

McKee, K. E., & Hackney, M. E. (2013). The effects of adapted tango on spatial cognition and disease severity in Parkinson's disease. *Journal of Motor Behavior, 45,* 519–529. http://dx.doi.org/10.1080/00222895.2013.834288

Mehr, S. A. (2015). Miscommunication of science: Music cognition research in the popular press. *Frontiers in Psychology, 6,* 988. http://dx.doi.org/10.3389/fpsyg.2015.00988

Mehr, S. A., Schachner, A., Katz, R. C., & Spelke, E. S. (2013). Two randomized trials provide no consistent evidence for nonmusical cognitive benefits of brief preschool music enrichment. *PLoS ONE, 8*(12), e82007. http://dx.doi.org/10.1371/journal.pone.0082007

Merrett, D. L., Peretz, I., & Wilson, S. J. (2013). Moderating variables of music training-induced neuroplasticity: A review and discussion. *Frontiers in Psychology, 4,* 606. http://dx.doi.org/10.3389/fpsyg.2013.00606

Miendlarzewska, E. A., & Trost, W. J. (2014). How musical training affects cognitive development: Rhythm, reward and other modulating variables. *Frontiers in Neuroscience, 7,* 279. http://dx.doi.org/10.3389/fnins.2013.00279

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49–100. http://dx.doi.org/10.1006/cogp.1999.0734

Moradzadeh, L., Blumenthal, G., & Wiseheart, M. (2015). Musical training, bilingualism, and executive function: A closer look at task switching and dual-task performance. *Cognitive Science, 39,* 992–1020. http://dx.doi.org/10.1111/cogs.12183

Moreau, D., & Conway, A. R. (2013). Cognitive enhancement: A comparative review of computerized and athletic training programs. *International Review of Sport and Exercise Psychology, 6,* 155–183. http://dx.doi.org/10.1080/1750984X.2012.758763

Moreno, S., Bialystok, E., Barac, R., Schellenberg, E. G., Cepeda, N. J., & Chau, T. (2011). Short-term music training enhances verbal intelligence and executive function. *Psychological Science, 22,* 1425–1433. http://dx.doi.org/10.1177/0956797611416999

Moreno, S., & Bidelman, G. M. (2014). Examining neural plasticity and cognitive benefit through the unique lens of musical training. *Hearing Research, 308,* 84–97. http://dx.doi.org/10.1016/j.heares.2013.09.012

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning & Verbal Behavior, 16,* 519–533. http://dx.doi.org/10.1016/S0022-5371(77)80016-9

Mosing, M. A., Madison, G., Pedersen, N. L., & Ullén, F. (2016). Investigating cognitive transfer within the framework of music practice: Genetic pleiotropy rather than causality. *Developmental Science, 19,* 504–512. http://dx.doi.org/10.1111/desc.12306

Münte, T. F., Altenmüller, E., & Jäncke, L. (2002). The musician's brain as a model of neuroplasticity. *Nature Reviews Neuroscience, 3,* 473–478. http://dx.doi.org/10.1038/nrn843

Neville, H., Andersson, A., Bagdade, O., Bell, T., Currin, J., Fanning, J., . . . Sabourin, L. (2008). Effects of music training on brain and cognitive development in under-privileged 3- to 5-year-old children: Preliminary results. In B. Rich & C. Asbury (Eds.), *Learning, arts, and the brain: The Dana Consortium report on arts and cognition* (pp. 105–106). New York, NY: Dana Press.

Nickerson, R. S. (2000). Null hypothesis significance testing: A review of an old and continuing controversy. *Psychological Methods, 5,* 241–301. http://dx.doi.org/10.1037/1082-989X.5.2.241

Noack, H., Lövdén, M., Schmiedek, F., & Lindenberger, U. (2009). Cognitive plasticity in adulthood and old age: Gauging the generality of cognitive intervention effects. *Restorative Neurology and Neuroscience, 27,* 435–453.

Olsson, C. J. (2012). Dancing combines the essence for successful aging. *Frontiers in Neuroscience, 6,* 155. http://dx.doi.org/10.3389/fnins.2012.00155

Ontario Ministry of Education. (2009). The Ontario Curriculum. Grades 1–8: The Arts, 2009 (revised). Retrieved from http://www.edu.gov.on.ca/eng/curriculum/elementary/arts.html

Opacic, T., Stevens, C., & Tillmann, B. (2009). Unspoken knowledge: Implicit learning of structured human dance movement. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35,* 1570–1577. http://dx.doi.org/10.1037/a0017244

Paap, K. R., & Sawi, O. (2014). Bilingual advantages in executive functioning: Problems in convergent validity, discriminant validity, and the identification of the theoretical constructs. *Frontiers in Psychology, 5,* 962. http://dx.doi.org/10.3389/fpsyg.2014.00962

Palmer, C., & Deutsch, D. (2013). Music performance: Movement and coordination. *Psychology of Music, 3,* 405–422.

Pearce, M., & Rohrmeier, M. (2012). Music cognition and the cognitive sciences. *Topics in Cognitive Science, 4,* 468–484. http://dx.doi.org/10.1111/j.1756-8765.2012.01226.x

Portowitz, A., Lichtenstein, O., Egorova, L., & Brand, E. (2009). Underlying mechanisms linking music education and cognitive modifiability. *Research*

Studies in Music Education, 31, 107–128. http://dx.doi.org/10.1177/1321103X09344378

Roden, I., Grube, D., Bongard, S., & Kreutz, G. (2014). Does music training enhance working memory performance? Findings from a quasi-experimental longitudinal study. *Psychology of Music, 42,* 284–298. http://dx.doi.org/10.1177/0305735612471239

Roden, I., Könen, T., Bongard, S., Frankenberg, E., Friedrich, E. K., & Kreutz, G. (2014). Effects of music training on attention, processing speed and cognitive music abilities—Findings from a longitudinal study. *Applied Cognitive Psychology, 28,* 545–557. http://dx.doi.org/10.1002/acp.3034

Rodrigues, A. C., Loureiro, M. A., & Caramelli, P. (2010). Musical training, neuroplasticity and cognition. *Dementia & Neuropsychologia, 4,* 277–286. http://dx.doi.org/10.1590/S1980-57642010DN40400005

Rogosa, D. R., & Willett, J. B. (1983). Demonstrating the reliability of the difference score in the measurement of change. *Journal of Educational Measurement, 20,* 335–343. http://dx.doi.org/10.1111/j.1745-3984.1983.tb00211.x

Rohrmeier, M., & Rebuschat, P. (2012). Implicit learning and acquisition of music. *Topics in Cognitive Science, 4,* 525–553. http://dx.doi.org/10.1111/j.1756-8765.2012.01223.x

Royer, J. M., Mestre, J. P., & Dufresne, R. (2005). Introduction: Framing the transfer problem. In J. Mestre (Ed.), *Transfer of learning from a modern multidisciplinary perspective* (pp. vii–xxvii). Greenwich, CT: Information Age.

Sala, G., & Gobet, F. (2017a). Experts' memory superiority for domain-specific random material generalizes across fields of expertise: A meta-analysis. *Memory and Cognition, 45,* 183–193. http://dx.doi.org/10.3758/s13421-016-0663-2

Sala, G., & Gobet, F. (2017b). When the music's over: Does music skill training transfer to children's and young adolescents' cognitive and academic skills? A meta-analysis. *Educational Psychology Review, 20,* 55–67. http://dx.doi.org/10.1016/j.edurev.2016.11.005

Salthouse, T. A. (1993). Speed mediation of adult age differences in cognition. *Developmental Psychology, 29,* 722–738. http://dx.doi.org/10.1037/0012-1649.29.4.722

Salthouse, T. A. (1994). The nature of the influence of speed on adult age differences in cognition. *Developmental Psychology, 30,* 240–259. http://dx.doi.org/10.1037/0012-1649.30.2.240

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103,* 403–428. http://dx.doi.org/10.1037/0033-295X.103.3.403

Salthouse, T. A., & Meinz, E. J. (1995). Aging, inhibition, working memory, and speed. *The Journals of Gerontology: Series B, Psychological Sciences and Social Sciences, 50B,* P297–P306. http://dx.doi.org/10.1093/geronb/50B.6.P297

Satoh, M., Ogawa, J., Tokita, T., Nakaguchi, N., Nakao, K., Kida, H., & Tomimoto, H. (2014). The effects of physical exercise with music on cognitive function of elderly people: Mihama-Kiho project. *PLoS ONE, 9* (4), e95230. http://dx.doi.org/10.1371/journal.pone.0095230

Schafer, J. L. (1999). Multiple imputation: A primer. *Statistical Methods in Medical Research, 8,* 3–15. http://dx.doi.org/10.1177/096228029900800102

Schellenberg, E. G. (2004). Music lessons enhance IQ. *Psychological Science, 15,* 511–514. http://dx.doi.org/10.1111/j.0956-7976.2004.00711.x

Schellenberg, E. G. (2006). Long-term positive associations between music lessons and IQ. *Journal of Educational Psychology, 98,* 457–468. http://dx.doi.org/10.1037/0022-0663.98.2.457

Schellenberg, E. G. (2009). Musikunterricht, geistige Fähigkeiten und Sozialkompetenzen: Schlussfolgerungen und Unklarheiten [Music lessons, intellectual abilities, and social skills: Conclusions and confusionsReview of General PsychologyBundesministerium für Bildung und Forschung (Eds.), *Pauken mit Trompeten? Lassen sich Lernstrategien, Lernmotivation und soziale Kompetenzen durch Musikunterricht fördern?* (pp. 114–124). Bonn/Berlin, Germany: Bundesministerium für Bildung und Forschung.

Schellenberg, E. G. (2011). Examining the association between music lessons and intelligence. *British Journal of Psychology, 102,* 283–302. http://dx.doi.org/10.1111/j.2044-8295.2010.02000.x

Schellenberg, E. G. (2016). Music training and nonmusical abilities. In S. Hallam, I. Cross, & M. Thaut (Eds.), *The Oxford handbook of music psychology* (2nd ed., pp. 415–429). Oxford, UK: Oxford University Press.

Schellenberg, E. G., & Winner, E. (2011). Music training and nonmusical abilities: Introduction. *Music Perception, 29,* 129–132. http://dx.doi.org/10.1525/mp.2011.29.2.129

Sedgwick, P. (2015a). Randomised controlled trials: Understanding effect sizes. *British Medical Journal, 350,* h1690. http://dx.doi.org/10.1136/bmj.h1690

Sedgwick, P. (2015b). Treatment effects and placebo effects. *British Medical Journal: British Medical Journal, 350,* h267. http://dx.doi.org/10.1136/bmj.h267

Seinfeld, S., Figueroa, H., Ortiz-Gil, J., & Sanchez-Vives, M. V. (2013). Effects of music learning and piano practice on cognitive function, mood and quality of life in older adults. *Frontiers in Psychology, 4,* 810. http://dx.doi.org/10.3389/fpsyg.2013.00810

Sevdalis, V., & Keller, P. E. (2011). Captured by motion: Dance, action understanding, and social cognition. *Brain and Cognition, 77,* 231–236. http://dx.doi.org/10.1016/j.bandc.2011.08.005

Singley, M. K., & Anderson, J. R. (1989). *The transfer of cognitive skill*. Cambridge, MA: Harvard University Press.

Slagter, H. A., Davidson, R. J., & Lutz, A. (2011). Mental training as a tool in the neuroscientific study of brain and cognitive plasticity. *Frontiers in Human Neuroscience, 5,* 17. http://dx.doi.org/10.3389/fnhum.2011.00017

Slater, J., Tierney, A., & Kraus, N. (2013). At-risk elementary school children with one year of classroom music instruction are better at keeping a beat. *PLoS ONE 8*(10), e77250. http://dx.doi.org/10.1371/journal.pone.0077250

Slevc, L. R., Davey, N. S., Buschkuehl, M., & Jaeggi, S. M. (2016). Tuning the mind: Exploring the connections between musical ability and executive functions. *Cognition, 152,* 199–211. http://dx.doi.org/10.1016/j.cognition.2016.03.017

Statistics Canada. (2007a). Aurora, Ontario (Code3519046) [Table]. 2006 Community Profiles. 2006 Census. Statistics Canada Catalogue no. 92–591-XWE. Retrieved from http://www12.statcan.ca/census-recensement/2006/dp-pd/prof/92-591/index.cfm?Lang=E

Statistics Canada. (2007b). Halton Hills, Ontario (Code3524015) [Table]. 2006 Community Profiles. 2006 Census. Statistics Canada Catalogue no. 92–591-XWE. Retrieved from http://www12.statcan.ca/census-recensement/2006/dp-pd/prof/92-591/index.cfm?Lang=E

Strait, D. L., Slater, J., O'Connell, S., & Kraus, N. (2015). Music training relates to the development of neural mechanisms of selective auditory attention. *Developmental Cognitive Neuroscience, 12,* 94–104. http://dx.doi.org/10.1016/j.dcn.2015.01.001

Tillmann, B. (2005). Implicit investigations of tonal knowledge in nonmusician listeners. *Annals of the New York Academy of Sciences, 1060,* 100–110. http://dx.doi.org/10.1196/annals.1360.007

Thorndike, E. L., & Woodworth, R. S. (1901). The influence of improvement in one mental function upon the efficiency of other functions (I). *Psychological Review, 8,* 247–261. http://dx.doi.org/10.1037/h0074898

Tillmann, B., & McAdams, S. (2004). Implicit learning of musical timbre sequences: Statistical regularities confronted with acoustical (dis)similarities. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30,* 1131–1142. http://dx.doi.org/10.1037/0278-7393.30.5.1131

Van Ginkel, J. R. (2010). *SPSS syntax for applying rules for combining multivariate estimates in multiple imputation*. MI-MUL2.sps [Computer software]. Retrieved from http://www.socialsciences.leiden.edu/educationandchildstudies/childandfamilystudies/organisation/staffcfs/van-ginkel.html

Van Ginkel, J. R., & Kroonenberg, P. M. (2014). Analysis of variance of multiply imputed data. *Multivariate Behavioral Research, 49,* 78–91. http://dx.doi.org/10.1080/00273171.2013.855890

Verghese, J. (2006). Cognitive and mobility profile of older social dancers. *Journal of the American Geriatrics Society, 54,* 1241–1244. http://dx.doi.org/10.1111/j.1532-5415.2006.00808.x

Wechsler, D. (1991). *Manual for Wechsler Intelligence Scale for Children*. (3rd ed.). San Antonio, TX: The Psychological Corporation.

Williams, P. E., Weiss, L. G., & Rolfhus, E. L. (2003). *Psychometric properties* (WISC–IV Tech. Rep. No. 2). San Antonio, TX: Psychological Corporation.

Willoughby, M., & Blair, C. (2011). Test-retest reliability of a new executive function battery for use in early childhood. *Child Neuropsychology, 17,* 564–579. http://dx.doi.org/10.1080/09297049.2011.554390

Winner, E., & Cooper, M. (2000). Mute those claims: No evidence (yet) for a causal link between arts study and academic achievement. *Journal of Aesthetic Education, 34,* 11–75. http://dx.doi.org/10.2307/3333637

Wiseheart, M., Viswanathan, M., & Bialystok, E. (2016). Flexibility in task switching by monolinguals and bilinguals. *Bilingualism (Cambridge, England), 19,* 141–146. http://dx.doi.org/10.1017/S1366728914000273

Xu, F., Han, Y., Sabbagh, M. A., Wang, T., Ren, X., & Li, C. (2013). Developmental differences in the structure of executive function in middle childhood and adolescence. *PLoS ONE, 8* (10), e77770. http://dx.doi.org/10.1371/journal.pone.0077770

Zelazo, P. D., Anderson, J. E., Richler, J., Wallner-Allen, K., Beaumont, J. L., & Weintraub, S. (2013). II. NIH toolbox cognition battery (CB): Measuring executive function and attention. *Monographs of the Society for Research in Child Development, 78,* 16–33. http://dx.doi.org/10.1111/mono.12032

Zuk, J., Benjamin, C., Kenyon, A., & Gaab, N. (2014). Behavioral and neural correlates of executive functioning in musicians and non-musicians. *PLoS ONE, 9* (6), e99868. http://dx.doi.org/10.1371/journal.pone.0099868

Received August 11, 2017
Revision received February 26, 2018
Accepted April 23, 2018 ■