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The sound of self-regulation: Music program relates to an advantage for children at risk

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ABSTRACT

Promoting self-regulatory development represents a critical concern for all early childhood educational programs, and particularly those serving children at risk via poverty. Stressors related to poverty tax children's physiological stress-response systems and self-regulatory capacities, challenging healthy development. The present study examined an early childhood music intervention designed to promote children's self-regulatory skill development. The participants were 191 children ages 3-5 years old who faced economic hardship. A quasi-experimental, stepped-wedge design that included four preschools and 3 study years facilitated comparing across the school year children who received preschool programming as usual (n = 43) with those who additionally received the music intervention (n =148). Well validated child assessments measured the inhibitory control aspect of self-regulation, as well as receptive vocabulary, and a parent interview measured demographic covariates. Core analyses with hierarchical linear modeling revealed that, compared with peers who received programming as usual, children who received the music intervention showed greater growth in inhibitory control across the preschool year. Implications concern the potential for early childhood music programming to promote self-regulation and support positive development for children facing economic hardship.

1. Introduction

Worldwide, as well as within the United States, approximately 43% of children are growing up in households classified as poor or low-income based on the threshold of less than $13 dollars a day (U.S. Census Bureau, 2016; World Bank, 2017). The impact is clear: Economic hardship places children at risk for a host of difficulties in cognitive and social-emotional domains (Brooks-Gunn & Duncan, 1997; Duncan & Brooks-Gunn, 2000; Yoshikawa, Aber & Beardslee, 2012). In the United States, early childhood programs such as Head Start preschool have been demonstrated to promote positive development but fall short of equalizing educational outcomes for children at risk via poverty (U.S. Department of Health & Human Services, 2010). Although early childhood programs cannot be expected to erase the impact of poverty (Brooks-Gunn, 2003), it is incumbent upon us to continue exploring how we might promote positive outcomes for children facing economic hardship. Supporting the development of self-regulation matters centrally for this goal (Blair & Raver, 2015).

Children's development of self-regulation, which can be conceptualized as the ability to successfully manage emotions, attention, and behavior in the service of learning and prosocial engagement, is widely recognized as a prerequisite for school success (Hamre & Pianta, 2001; McClelland et al., 2014; Miller, Gouley, Seifer, Dickstein, & Shields, 2004; Raver & Knitzer, 2002; Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009). Support for this area of development may be particularly important for children growing up in poverty, as poverty-related stressors tax regulatory capacities (Evans, 2003), undermining their healthy development across early childhood and beyond (Blair & Raver, 2012). For these reasons, fostering self-regulatory capacities is important for all early childhood programs and particularly so for those serving children in poverty (Blair & Raver, 2015). The present study examined an early childhood music intervention designed to promote children's self-regulatory skill development across a year of preschool attendance.

2. Self-regulation for children facing economic hardship

Across the preschool years, the management of emotions, attention, and behavior transitions from a process of co-regulation, mediated by caregiver interactions, to one of self-regulation, mediated by independently controlled cognitive processes (Diamond, 2002). These cognitive processes involve "executive functions" such as strategic planning, working memory, attention, and inhibitory control, or the suppression of prepotent responses in favor of ones that

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better support goal attainment (Diamond, 2013). In the classroom setting, inhibitory control might allow a child whose peer takes a toy away to suppress the dominant response of grabbing the toy back in favor of a more socially desirable one of using words to ask for it. Inhibitory control also would serve to help children to follow instructions for preacademic tasks, resisting external or internal distractions to achieve desired outcomes (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014).

Inhibitory control and other aspects of self-regulation predict variance in preacademic school readiness beyond that accounted for by measures of general intelligence and processing speed (Fitzpatrick et al., 2014). Blair and Razza (2007), for example, established a link between self-regulatory components such as inhibitory control and the development of literacy and numeracy for children in Head Start preschool. Also, Welsh, Nix, Blair, Bierman, and Nelson (2010) study of children in Head Start revealed that growth in aspects of self-regulation predicted literacy and numeracy skill development across the preschool year as well as the kindergarten year.

Self-regulatory abilities are particularly important for children in poverty circumstances, who face disproportionate challenges (Evans, 2004). Yet the same poverty-related stressors that demand children employ effective self-regulatory strategies, also challenge their development (Blair & Raver, 2012; Evans, 2003). Poverty-related instability and chaos, for example, can compromise the predictable and supportive proximal processes (e.g., caregiver-child interactions) needed to build self-regulatory skills (Fiese & Winter, 2010). Moreover, poverty environments are replete with circumstances that undermine the functioning of the brain areas involved in self-regulation (Blair & Raver, 2012). Key among these is the prefrontal cortex; an area rich in receptors for hormones like cortisol, which help individuals marshal physiological resources to respond to stress or challenge (Arnsten, 2009). Under supportive environmental conditions, an abundance of cortisol receptors in the prefrontal cortex supports effective self-regulation, helping children engage physiological resources for cognitive processing (Ramos & Arnsten, 2007). Yet chronic stress takes a toll, overburdening physiological stress response systems and impairing the prefrontal cortex and associated self-regulatory capacities (Blair & Raver, 2012; Blair et al., 2011; Evans, 2003; Evans & Schamberg, 2009; Ursache, Blair, Stifter, & Voegtline, 2013).

A robust research base has documented the impact of poverty-related stress on self-regulation. Raver, Blair and Willoughby (2013) followed young children living in low-income households from age 7 months through 4 years and found that the duration and severity of poverty as well as parent-reported financial strain predicted problems with self-regulation. Also, in a longitudinal study of children facing economic hardship, Evans and colleagues documented that high allostatic load or burden on physiological systems that respond to stress predicted self-regulatory problems across the school years and into adulthood (e.g., Doan & Evans, 2011; Evans, 2003; Evans, & Schamberg, 2009). Stress related to systemic racism also has been implicated as a risk for self-regulatory difficulties (Brown, Anderson, Garnett & Hill, 2019; Peterson, Stock, Monroe, Molloy-Paolillo, & Lambert, 2020). Concomitantly, research has elucidated considerable diversity in self-regulatory functioning among children facing poverty and racism as well as environmental factors that may support resilience in the face of adversity (Blair & Diamond, 2008).

3. Preschool interventions to promote self-regulation

Promoting self-regulatory development is important for all early childhood programs, and imperative for those serving children who face economic hardship and related adversity (Blair & Raver, 2015). Yet these programs also often face pressure to focus on kindergarten prerequisite knowledge of letters, numbers, colors, shapes, and sizes. Thus, although many early childhood curricula include some focus on self-regulatory development, more may be needed (Singer, Golinkoff, & Hirsh-Pasek, 2006). Positive self-regulatory effects have been associated with several early childhood interventions, including the Preschool Promoting Alternative Thinking Strategies program (PATHS; Domitrovich, Cortes, & Greenberg, 2007; Riggs et al., 2006), Emotions Based Prevention program (EBP; Izard et al., 2008; Izard, Trentacosta, King, & Mostow, 2004); Chicago School Readiness Project (CSRP; Raver et al., 2009, 2011); Research based Developmental Informed (REDI) project (Bierman, Domitrovich et al., 2008; Bierman, Nix et al., 2008); Tools of the Mind (Blair & Raver, 2014; Bodrova & Leong, 2007; Diamond, Barnett, Thomas, & Munro, 2007), Improve Your Emotional Skills (I-YES; 2020), and KidsMatter Early Childhood (Slee et al., 2012).

Some of these programs have involved teacher training. For example, the CSRP included 30 hours of teacher training in classroom management strategies for providing children with effective regulatory support. Across a year of Head Start preschool, children who received the program diverged from comparison peers in terms of teacher-rated behavioral difficulties as well as observer-rated attention and impulse control, and performance-based measures of inhibitory control and working memory (Raver et al., 2009, 2011).

Other interventions have focused on building self-regulatory skills via interactive curricula. For example, the REDI program was designed to promote emotion awareness and behavior regulation via interactive language and literacy experiences. Bierman et al. (2008a) found positive effects on executive function and inhibition, which partially mediated program effects on literacy (2008b). Also, the Vygotskian Tools of the Mind program was designed to foster the development of executive functioning via child-directed sociodramatic play. Although effects have differed for specific outcomes and their sustainability (e.g., Blair, McKinnon, & Daneri, 2018), both a small-scale randomized evaluation of the preschool version (Diamond et al., 2007) and a more recent large-scale cluster randomized-controlled trial of the kindergarten version indicated positive effects on self-regulatory outcomes (Blair & Raver, 2014). These results suggest the potential for fostering self-regulation via creative activities, and emergent research on early childhood music programs stands in accord (Menzer, 2015).

4. Music and self-regulation

There are several theoretical reasons why music programming may build self-regulatory skills. First, such programming may support children's development of promotive discrete emotion systems, which, according to differential emotions theory, develop as emotions are activated in response to environmental experiences, eventually giving rise to characteristic patterns of emotions, cognitions, and actions (Abe & Izard, 1999; Izard, 1971, 1992). To the extent that music programming provides opportunities for experiencing interest, happiness, and pride, it might contribute to discrete emotion systems that support self-regulation in preschool, as well as across the transition to formal schooling (Abe & Izard, 1999; Brown & Sax, 2013).

Second, such programming might build skills for regulating emotion. In a systematic review, Juslin and Laukka (2003) presented evidence that vocal expression of emotion and musical expression of emotion are similar in the accuracy with which discrete emotions are communicated to listeners and the emotion-specific patterns of acoustic cues used to communicate each emotion. Given the emotion communicated by music, certain early childhood music programs might promote emotion recognition, which is considered a prerequisite for independent emotion regulation (Denham, 1998; Denham et al., 2012), as well as facilitate

children's practice with strategies for regulating emotions via music and movement (Brown & Sax, 2013). These assumptions are built into many existing music therapy programs such as Growing with Music, a UNICEF-led program for young children in Costa Rica (UNICEF, 2012).

Third, early childhood music programming may promote self-regulation by providing opportunities to practice strategies for inhibitory control and behavioral regulation. Research has documented benefits of programs using music to facilitate children's practice with turn taking and social reciprocity, such as the Sing & Grow music therapy program (Williams, Berthelsen, Nicholson, Walker, & Abad, 2012) and the Kindermusik music education program (Winsler, Duceene, & Koury, 2011). Winsler and colleagues found that, compared to peers in a control group, children in Kindermusik used more private speech as well as singing and humming to themselves, which seemed to enhance their performance on self-regulatory tasks. The researchers concluded that opportunities to modulate behavior in response to musical cues such as stop/start, slow/fast, and loud/soft helped children develop behavioral control (Winsler et al., 2011). This idea matches findings from the Longitudinal Study of Australian Children, which showed that the parent-reported frequency of shared music activities when the child was between the age of 2 and 3 years related to prosocial skills and attentional regulation as well as numeracy 2 years later (Williams, Barrett, Welch, Abad, & Broughton, 2015).

An emergent research base supports the self-regulatory benefits of high quality music programs for preschool children facing economic hardship (Menzer, 2015). In a 2006 experimental study by Lobo and Winsler, children attending a Head Start preschool were randomly assigned to an 8-week experimental dance/creative movement program or a control group with free play. Those assigned to dance showed greater pre-to-post program growth in social competence and internalizing and externalizing behavior as rated by parents and teachers. The researchers noted the opportunities afforded by dance instruction for building social skills and self-regulatory strategies and concluded that creative dance instruction might enhance social-emotional competence for children at risk via economic hardship (Lobo & Winsler, 2006).

In a 2013 study, Brown and Sax examined child emotions within Settlement Music School's arts-integrated Head Start preschool where children received daily music, dance, and visual arts classes taught by credentialed artist teachers. Children in this preschool showed greater incidence of positive emotions in the music and arts classes compared with regular early learning or homeroom and showed 60% more positive emotions overall than those at a comparison Head Start without arts classes. Although children at both preschools showed growth over the course of the year in the ability to regulate negative emotions, the growth from start- to end-of-year was approximately five times greater at the arts-integrated preschool (Brown & Sax, 2013). A further study of the arts-integrated preschool revealed lower levels of the stress hormone cortisol during the music, dance, and visual arts classes (Brown, Garnett, Anderson, & Laurenceau, 2017).

These prior studies provide compelling evidence of the potential for music programming to promote young children's self-regulatory development. Yet whereas several past experimental or quasi-experimental studies of self-regulation have investigated the impact of early childhood music classes, none we know of have focused on alternative models such as the integration of music into regular early childhood classrooms by an inhouse or visiting artist teacher or by the homeroom teacher, potentially with guidance from an artist teacher. Understanding the potential for music integration to enhance social-emotional development matters for policy and practice regarding access to music for children facing economic hardship.

4.1. Present study

The present study examined the impact of MacPhail Center for Music's Learning with Music Program on self-regulatory skill development for young children facing economic hardship. Learning with Music is a preschool music integration program available through a broader initiative called Sing, Play, Learn with MacPhail. In Learning with Music, MacPhail Center for Music's credentialed music teachers partner with preschools and early childhood development centers to educate teachers, administrators, and parents about the value of music learning and train teachers in how to integrate music into the early childhood curriculum. MacPhail's music teachers regularly visit preschool classrooms during the training phase and model leading group music activities as well as adding songs, chants, and musical stories to ease transitions, support task accomplishment, help children to regulate or manage emotions and behavior, and aid in teaching pre-literacy and numeracy skills.

MacPhail Center for Music's Learning with Music Program stands out because of its focus on training early childhood teachers to integrate music. When Nardo, Custodero, Persellin, and Fox (2006) surveyed teachers in NAEYC-accredited preschools, a majority reported using the arts to teach school readiness skills; a song to teach days of the week or a dance to teach following directions, for example. Yet these teachers reported using arts components such as music for a small amount of time each day, and primarily to enrich the classroom environment. Promoting social-emotional and other pre-academic skill development was ranked as the least important reason for using the arts. The MacPhail Learning with Music Program was developed in response to a recognized need for training early childhood teachers in music integration (see Barrett, Zhukov & Welch, 2019). Such training could provide a cost-effective alternative to resident artist teachers and provide access for children who might not otherwise benefit from music education.

The present investigation is the first published study to examine the impact of MacPhail's Learning with Music Program. We hypothesized that this program would be associated with an advantage in self-regulatory growth across the preschool year.

5. Method

5.1. Study design

In this quasi-experimental study, which included four preschools and 3 study years, we compared growth in the inhibitory control aspect of self-regulation for children receiving MacPhail's Learning with Music Program versus those receiving preschool programming as usual. Preschools were selected for participation based on a combination of convenience sampling (geographic proximity to MacPhail), purposive sampling (served children facing economic hardship and were matched on key indicators of quality and curriculum), and also expressed clear interest (voluntary response). The preschools selected were private, community-based preschools that used the Creative Curriculum (the most common early childhood curriculum in the US), and the Doors to Discovery preliteracy program. All were accredited by the National Association for the Education of Young Children (NAEYC) and had the highest possible early childhood program rating according to the State rating system. Lead teachers held bachelor's degrees in education and assistants held associates degrees. Classes were grouped according to child age, and teacher-to-child ratios ranged from 1:7 to 1:10. Two preschools not included in the present study were also identified as matched on these characteristics and did not indicate clear interest in hosting the program and associated study.

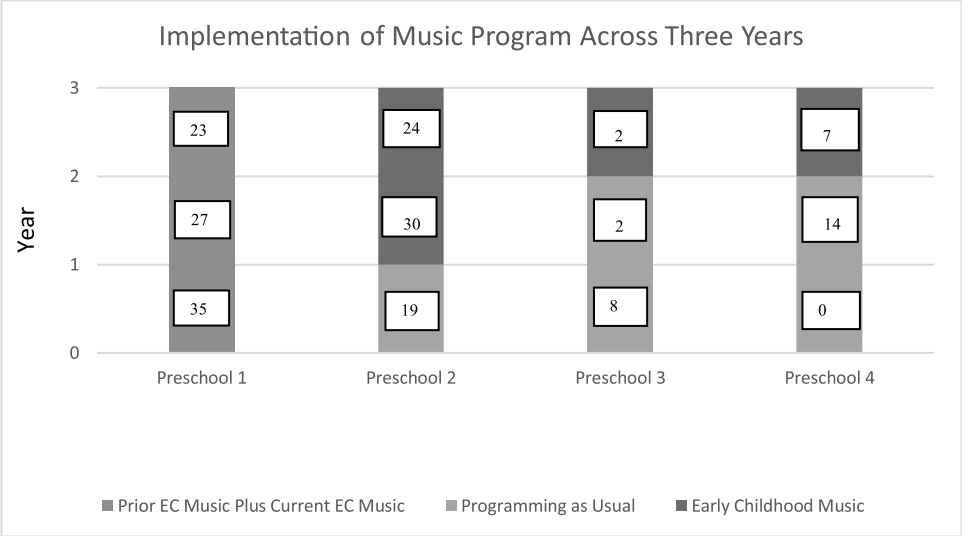

Figure 1. Implementation of MacPhail's Early Childhood (EC) Learning with Music Program across Three Years (N = 191)Note. The figure provides a visual representation of programming as usual (without Early Childhood Music) versus with Early Childhood Music for each of the four preschools across the 3 study years and indicates the numbers of children who participated during each study year at each preschool. In total, 148 children received MacPhail's Early Childhood Learning with Music Program and 43 did not. [1]Preschool 1 had received MacPhail's Early Childhood Learning with Music Program prior to the start of the present study. [2]Preschool 4 was not studied in Year 1.

In terms of the participating preschools, Preschool 1 had received MacPhail's Learning with Music Program for 9 years prior to the study and received the music program in all 3 study years. Preschools 2 and 3 were initially selected for comparison purposes and Preschool 4 was added in Year 2 due to low enrollment in Preschool 3. In Year 1, Preschool 1 received the Music Program and Preschools 2, 3, and 4 received programming as usual (but Preschool 4 was not yet in the study). In Year 2, all four preschools were in the study, and Preschools 1 and 2 received the Music Program whereas 3 and 4 received programming as usual. In Year 3, all four preschools received the Music Program. Fig. 1 provides a visual representation of when each preschool received the music intervention versus programming as usual.

5.2. Intervention: MacPhail's Learning with Music Program

MacPhail Center for Music's Learning with Music Program; a program of Sing, Play, Learn with MacPhail, was implemented by a teacher who had a BA in music therapy, certification as a music therapist, and 8 years of experience implementing this program. The central component was visits to preschools to implement and model music integration 24 times per school year for 2 hours per session. In these visits, the MacPhail teacher led 30 minute group music activities such as singing songs and beating rhythm sticks and also modeled integrating music into other activities to promote learning of early childhood concepts such as letters and numbers as well as help children appropriately manage or regulate their emotions.

For example, if children were playing with alphabet blocks, the MacPhail teacher might sit nearby and sing a song about the letters, pointing to the correspondent blocks. If children were transitioning from one activity to another, the MacPhail teacher might sing a song to help children to manage their emotions during the transition. Examples might be a cleanup song to help children manage emotions and behavior during the process of cleaning up or a lining up song to help children regulate their emotions and behavior as they lined up to walk down the hall to go outside. In situations that might elicit frustration or anger, such as a child's block tower being knocked over by a peer, the MacPhail teacher might sing a problem-solving song about, "what I can do when I'm mad," or a calming song, paired with physical contact such as hand holding. In many cases, the songs were made up spontaneously by putting new words to familiar tunes. For example, as children waited in line to take turns shooting a basketball, the MacPhail teacher might sing to the tune of "Row, Row, Row Your Boat," words like, "Wait, wait, wait my turn, for the basketball. I can watch my friends take turns, as I stand still and tall." The goal was for preschool teachers to learn how they might use simple songs similarly, to help children regulate emotions and behavior during challenging situations.

Additional components of the MacPhail Early Childhood Learning with Music Program included: a 2 hour start-of-year training for preschool teachers; 1 hour planning, progress, and evaluation meetings with administrators and teachers at the start, middle, and end of the year; 15 minute weekly meetings with teachers to share ideas and check progress; and one or two 1 hour family events to show the families what children were learning, educate parents about the benefits of music integration, and share sing and play along activities that might be implemented at home.

5.3. Participants

This study included 191 child participants in an initial year of preschool attendance at one of four preschools in a Midwestern U.S. city in one of three school year cohorts between 2013 and 2016. In total, 148 children received the MacPhail Learning with Music Program and 43 did not. Approximately 59% were identified as female, 41% male, 47% Black/African Heritage, 19% Asian Heritage, 16% Latinx/Hispanic Heritage, and 18% White/European Heritage.

In accordance with federal guidelines, we divided each family's income by the poverty threshold for the respective family size to arrive at a family income-to-needs ratio. Mean income was $20,708 ($SD$ = 15,860, range = 0-43,000). Mean family size was 1.7 adults (SD = 0.61, range = 1-4) and 2.07 children (SD = 1.05, range = 1-10). A ratio of 1.0 represented the poverty line, and 2.0 represented low-income. Approximately 40% of children in the present study were living below the poverty threshold, 25% were below the threshold for low-income, and an additional 28% were living near this threshold, with income to needs ratios $\leq$3.0.

5.4. Procedure

Ethical standards were followed in the conduct of this study, and all procedures were approved by the appropriate IRBs. Recruitment took place in September and October, at the start of the preschool year. Parents or caregivers were provided a description of the study at preschool orientation and were given the opportunity to ask questions of a trained research assistant (RA) as well as provide informed consent, and complete demographic interviews. Interpretation was provided by the preschool. Children were eligible for participation if they were in an initial year of preschool attendance, and between the ages of 3 and 5 years old by September 1, with no severe developmental delays that would preclude their participation (no interested child had to be excluded on this basis). Study participation rates for eligible children were above 95% across preschools and study years. A single, trained RA completed assessments of child receptive vocabulary at the start (September and October) of the year and inhibitory control at the start, middle (January and February), and end (May and June) of the year.

5.5. Measures

5.5.1. Demographics

The demographic interview for caregivers provided information about standard indicators such as child age, gender, race/ethnicity, family size, and family income.

5.5.2. Receptive Vocabulary

Receptive vocabulary was measured using the Peabody Picture Vocabulary Test–III (PPVT-III; Dunn & Dunn, 1997). The PPVT is a well validated measure of receptive vocabulary with test–retest reliability of 0.89. Standardized scores were used for the present study, and the mean was 94.65 (SD = 16.91, range = 40–135).

5.5.3. Inhibitory Control

Three well validated child tasks that have been determined to be developmentally sensitive during the preschool period (Carlson, 2005; Petersen, Hoyniak, McQuillan, Bates & Staples, 2016) measured inhibitory control. Moderate to high correlations (r = 0.46 to 0.67) among tasks administered at the same time point supported standardizing (z-scoring based on the entire sample) and aggregating to form an overall index used for further analyses.

5.5.4. Day/Night Stroop

In this task (Gerstadt, Hong & Diamond, 1994), the RA talks with the child about when the sun comes up (day) and when the moon and stars come out (night), and then presents a white card with a yellow sun and a black card with a white moon and stars. The child is instructed to say “night” for the sun card and “day” for the moon and stars card. After a brief warm-up, there are 16 test trials, with each card presented in a fixed, pseudorandom order. For the present study, the mean for start-of-year was 11.11 (SD = 5.34, range = 0-16), midyear was 13.76 (SD = 3.61, range = 0-16), and end-of-year was 14.87 (SD = 2.75, range = 0-16).

5.5.5. Peg Tapping

In this task (Diamond & Taylor, 1996), the child is instructed to tap twice with a wooden peg when the RA taps once, and once, when the RA taps twice. The task requires children to inhibit a natural tendency to mimic the action of the RA while remembering the rule for the correct response. After practice trials, there are 16 counterbalanced test trials. For the present study, the mean for start-of-year was 7.53 (SD = 6.54, range = 0-16), midyear was 11.54 (SD = 5.25, range = 0-16), and end-of-year was 13.55 (SD = 4.36, range = 0-16).

5.5.6. Bear/Dragon

In this task (Reed, Pien & Rothbart, 1984), the RA introduces the child to a “nice” bear puppet (using a soft, high-pitched voice) and a “naughty” dragon puppet (using a gruff, low-pitched voice). The experimenter explains that in this game the children are to do what the bear asks (e.g., touch your nose) but not what the dragon asks. After practice items, there are 10 test trials with bear and dragon commands in alternating order. All commands involve hand movements. Performance on dragon trials forms an index of self-control. For the present study, the mean for start-of-year was 8.43 (SD = 2.44, range = 0-10), midyear was 9.39 (SD = 1.47, range = 4-10), and end-of-year was 9.65 (SD = 1.25, range = 0-10).

5.6. Analytic approach

Analyses were designed to elucidate the impact of the Music Program versus preschool programming as usual on self-regulation. Preliminary analyses included descriptive statistics by preschool and condition as well as zero-order correlations among study variables. For core analyses, hierarchical linear modeling (HLMv7; Raudenbush, Bryk, Cheong, Congdon & du Toit, 2011) was used to examine the impact of time and condition on inhibitory control, with controls for verbal ability and demographic variables that hold demonstrated importance for self-regulatory outcomes.

HLM accounted for the hierarchical structure of the data, with inhibitory control scores at start-, middle-, and end-of-year time points “nested” within children. Notably children also were nested within classrooms and schools, but the data did not support these levels of analysis. HLM estimates model fixed effect coefficients as well as lower level or Level 1 (within-persons) and upper level or Level 2 (between-persons) random effects. HLM employs full maximum likelihood for valid estimation of parameters in the presence of missing data on outcome variables at certain time points, making the missing at random (MAR) assumption and case-wise deletion to handle missing data on predictors at certain time points. More specifically, MAR refers to the probability that missing an inhibitory control score at a particular time point may be related to inhibitory control scores from previous time points and to predictors such as age and sex, but not to the missing inhibitory control scores at that time point (Enders, 2010). In this study, all participants had complete data for start-of-year and midyear variables. Across preschools, 4 end-of-year data points for inhibitory control were missing due to children leaving the respective preschool (see Table 1). These participants did not differ statistically on measured variables but may have differed on variables not captured by the present study.

6. Results

6.1. Preliminary analyses

Table 1 displays descriptive statistics and tests of statistical difference for key study variables by preschools and condition (with or without the MacPhail Learning with Music Program). Tests of statistical difference compared Preschool 1, which had received the Music Program prior to the start of the study and received it in all 3 study years, to the other three preschools, which had not received the Music Program prior to the study and received it for just 1 or 2 study years. Compared with peers in the other programs, children from Preschool 1 were more likely to be Black/African Heritage, Latinx/Hispanic Heritage, or Asian Heritage versus White/European Heritage. The children from Preschool 1 also tended to have lower family income-to-needs ratios. The tests

Table 1
Descriptive statistics and tests of statistical difference for child variables ($N = 191$)[c,d].

	OverallM (SD)	School 1M (SD)	School 2M (SD)	School 3M (SD)	School 4M (SD)	Schools 2, 3, and 4M (SD)
Without Music n	43	—	19	10	14	43
Age	47.33 (7.26)	—	46.00 (6.74)	49.90 (7.91)	47.29 (7.51)	47.33 (7.26)
Sex	0.58 (0.50)[+]	—	0.68 (0.48)[+]	0.40 (0.52)	0.57 (0.51)	0.58 (0.50)[+]
Race	0.79 (0.41)	—	0.74 (0.45)	0.80 (0.42)	0.86 (0.36)	0.79 (0.41)
Family Income	1.41 (1.10)	—	1.48 (1.28)	0.78 (0.65)	1.73 (0.93)	1.41 (1.10)
Verbal Ability	92.58 (15.98)	—	95.74 (21.22)	86.30 (11.87)	92.79 (7.72)	92.58 (15.98)
Inhibitory Control						
Start-of-Year	−0.97 (2.80)	—	−1.15 (3.04)	−0.72 (3.62)	−0.92 (1.83)[+]	−0.97 (2.80)
Midyear	−0.12 (2.34)[+]	—	0.48 (2.57)	−0.71 (2.35)	−0.53 (1.94)	−0.12 (2.34)[+]
End-of-Year	.76 (2.28)[+]	—	0.88 (2.50)[+]	−0.01 (2.64)	1.13 (1.62)	.76 (2.28)[+]
With Music n	148	85	54	2	7	63
Age	48.09 (6.88)	48.95 (6.39)	47.04 (7.38)	52.00 (5.66)	44.71 (7.36)	46.94 (7.33)
t-test[a] (p value)	−0.63 (0.528)	−1.78 [b] (0.077)	−0.54 (0.592)	−0.35 (0.733)	0.74 (0.466)	0.16 (0.694)
Sex	0.36 (0.48)[+]	0.35 (0.48)	0.41 (0.50)[+]	0.00 (0.00)	0.29 (0.49)	0.38 (0.49)
t-test[a] (*P* value)	2.62 (0.009)**	0.44 [b] (0.658)	2.11 (0.038)*	1.05 (0.317)	1.22 (0.237)	3.91 (0.049)*
Race	0.83 (0.38)	0.94 (0.24)[#]	0.63 (0.49)	1.00 (0.00)	1.00 (0.00)	0.67 (0.47)[#]
t-test[a] (*P* value)	−0.59 (0.557)	−4.40 [b] (0.000)***	0.84 (0.404)	−0.65 (0.533)	−0.86 (0.400)	21.15 (0.00)***
Family Income	1.52 (1.18)	1.26 (0.98)[#]	1.92 (1.23)	0.00 (0.00)	1.90 (2.15)	1.86 (1.33)[#]
t-test[a] (*P* value)	−0.55 (0.577)	3.07 [b] (0.003)**	1.34 (0.185)	1.63 (0.137)	−0.23 (0.823)	3.45 (0.064)
Verbal Ability	95.32 (17.22)	94.53 (13.64)	96.75 (22.21)	89.25 (9.90)	91.29 (15.13)	96.24 (21.17)
t-test[a] (p value)	−0.93 (0.354)	0.60 [b] (0.552)	−0.17 (0.863)	−1.51 (0.161)	0.31 (0.764)	0.95 (0.33)
Inhibitory Control						
Start-of-Year	−0.91 (2.72)	−0.98 (2.49)	−0.57 (3.03)	0.19 (1.23)	−3.08 (2.31)[+]	−0.82 (3.01)
t-test [a] (*P* value)	−0.13 (0.897)	0.32 [b] (0.724)	−0.72 (0.472)	−0.34 (0.740)	2.34 (0.030)*	0.27 (0.792)
Midyear	0.77 (1.85)[+]	0.49 (1.96)[#]	1.35 (1.47)	2.18 (0.00)	−0.46 (2.18)	1.17 (1.64)[+,#]
t-test [a] (*P* value)	−2.63 (0.009)*	2.28 [b] (0.012)*	−1.79 (0.078)	−1.67 (0.125)	−0.07 (0.944)	−3.36 (0.00)***
End-of-Year	1.57 (1.16)[+]	1.41 (1.33)[#]	1.85 (0.83)[+]	2.18 (0.00)	1.38 (0.95)	1.81 (0.84)[+,#]
t-test [a] (*P* value)	−3.17 (0.002)*	2.14 [b] (0.017)*	−2.49 (0.015)*	−1.13 (0.284)	−0.38 (0.711)	−3.35 (0.00)***

Note. This table collapses data across time and organizes by school and by receipt of programming as usual versus the music intervention. Demographic variables are based on parent report at the time of study enrollment. Age is coded in months. Sex and risk associated with systemic racism are coded dichotomously (1 = male and Black/African Heritage, Latinx/Hispanic Heritage, or Asian Heritage (Black, Indigenous, or Person of Color), respectively).

[a] These t-tests correspond to the comparison of the without music (programming as usual) to with music (intervention) conditions.

[+] Indicates means associated with significant differences for these t-tests.

[b] These t-tests represent the comparison of School 1 (received music intervention prior to start of this study) to Schools 2, 3, and 4 (received music intervention for the first time during this study).

[#] Indicates means associated with significant differences for these t-tests.

[c] For inhibitory control quartiles: 25th = −1.21, 50th = 1.22, 75th = 2.18.

[d] For end-of-year inhibitory control: School 1 with music $n = 84$, School 2 with music $n = 53$, and School 3 without music $n = 8$.

* $P < 0.05$.

** $P < 0.01$.

*** $P < 0.001$.

did not reveal a statistically significant difference in start-of-year inhibitory control scores for children at Preschool 1 versus those at the other preschools.

Tests of statistical difference also compared children who received the MacPhail Learning with Music Program with those who received programming as usual. Overall, children who received the Music Program were more likely to be female. This statistical difference was evident also within Preschool 2. Here, children in the cohort that received the Music Program were more likely to be female than were their peers who received programming as usual in the prior year. For the inhibitory control index, statistical differences were not apparent for start-of-year scores but were apparent for mid- and end-of-year scores, with higher scores for those who received the Music Program compared with programming as usual. For those who did not receive the Music Program, preschool means for end-of-year scores fell between the 25th and 50th percentile for this sample, whereas mean end-of-year scores for those who received the Music Program fell between the 50th and 75th percentiles.

Table 2 displays zero-order correlations for key variables. Child age, race/ethnicity, and receptive vocabulary showed statistical relations with inhibitory control at start-, middle-, and end-of-year time points, with older children, those identified as White/European Heritage, and those with higher receptive vocabulary showing higher levels of inhibitory control. Family income also showed a statistical relation with inhibitory control at the end-of-year time point, with children who had higher family income-to-needs ratios showing greater inhibitory control.

6.2. Core analyses

The HLM included the dependent variable of inhibitory control at start-, middle-, and end-of-year time points as a function of a linear functional form of time, the child demographic variables and receptive vocabulary, and the music intervention. As indicated by the parameter estimates for the level-1 intercept, older children ($B = 0.182$, $P < 0.001$), those identified as White/European Heritage ($B = -0.859$, $P = 0.015$), and those with higher receptive vocabulary ($B = 0.073$, $P < 0.001$) showed statistically greater start-of-year inhibitory control. The relation linking music intervention condition to start-of-year inhibitory control was not significant. As indicated by the parameter estimates for the level-2 slope, inhibitory control scores tended to increase across the year ($B = 0.160$, $P = 0.002$). Children who were older ($B = -0.015$, $P < 0.001$), and those with higher start-of-year receptive vocabulary ($B = -0.007$, $P < 0.001$) tended to show less growth in inhibitory control. After accounting for the demographic and variables and receptive vocabulary, children who received the music intervention tended to show greater growth in inhibitory control across the year ($B = 0.130$, $P < 0.002$). With Cohen's $d = 0.48$, this can be interpreted as a medium size effect of the music intervention on inhibitory control.

Table 2
Zero-order correlations among key study variables ($N = 191$).

	1.	2.	3.	4.	5.	6.	7.	8.
1. Child age	–	0.03	0.00	−0.14**	0.15**	0.57**	0.48**	0.34**
2. Child sex		–	−0.09*	0.02	0.01	−0.01	−0.02	0.01
3. Child race			–	−0.14**	−0.24**	−0.22**	−0.27**	−0.19**
4. Family income				–	0.21**	0.01	0.07	0.12**
5. Verbal ability					–	0.57**	0.37**	0.38**
6. Inhibitory control- start-of-year						–	0.70**	0.57**
7. Inhibitory control- midyear							–	0.73**
8. Inhibitory control- end-of-year								–

Note. Age is coded in months. Sex and risk associated with systemic racism are coded dichotomously (1 = male and Black/African Heritage, Latinx/Hispanic Heritage, or Asian Heritage (Black, Indigenous, or Person of Color), respectively).
* $P < 0.05$.
** $P < 0.01$.

Table 3
Hierarchical linear model for child inhibitory control as a function of time, child demographics and verbal ability, and the music intervention ($N = 191$).

Fixed Effects for Level 1 Intercept, β_{0j}	B	S.E.	t	~df	p
Level 1 Intercept, γ_{00}	0.01	0.39	0.02	182	0.988
Age, γ_{01}	0.18	0.02	9.64	182	<0.001***
Sex, γ_{02}	−0.24	0.26	−0.90	182	0.369
Race, γ_{03}	−0.86	0.35	−2.46	182	0.015*
Income, γ_{04}	−0.04	0.12	−0.34	182	0.734
Verbal Ability, γ_{05}	0.07	0.01	9.12	182	<0.001***
Music, γ_{06}	−0.15	0.31	−0.50	182	0.621
Fixed Effects for Level 2 Slope, β_{1j}	B	S.E.	t	~df	p
Level 2 Intercept, γ_{10}	0.16	0.05	3.16	182	0.002
Child age, γ_{11}	−0.02	0.00	−5.89	182	<0.001***
Child sex, γ_{12}	0.04	0.03	1.05	182	0.295
Child race, γ_{13}	0.04	0.05	0.80	182	0.424
Income, γ_{14}	0.02	0.02	1.44	182	0.150
Verbal Ability, γ_{15}	−0.01	0.00	−6.50	182	<0.001***
Music, γ_{16}	0.13	0.04	3.19	182	0.002**

Note: The intercept represents start-of-year inhibitory control. Age is coded in months. Sex and risk associated with systemic racism are coded dichotomously (1 = male and Black/African Heritage, Latinx/Hispanic Heritage, or Asian Heritage (Black, Indigenous, or Person of Color), respectively). Random effects were estimated.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Post hoc analyses included a version of the HLM that did not include Preschool 1 (which had received the Music Program prior to this study). This HLM also demonstrated a medium-size statistical effect of the music intervention on inhibitory control (see Appendix A).

7. Discussion

Children's self-regulatory development represents an important focus for all early childhood education programs, and particularly for those serving children who face economic hardship (Hamre & Pianta 2001; McClelland et al., 2007; Miller et al., 2004; Raver & Knitzer, 2002; Rimm-Kaufman et al., 2009). Self-regulation undergirds school success, and its development is challenged by poverty risks, which overburden physiological stress response systems and undermine prefrontal cortex development (Blair & Raver, 2012). Emergent evidence suggests the potential for high quality early childhood music programming to promote self-regulatory development (Menzer, 2015), for example, by contributing to discrete emotion systems that support emotion regulation (Abe & Izard, 1999; Brown & Sax, 2013), and providing opportunities to develop and practice inhibitory control strategies (Winsler et al., 2011). The present study examined the effects of a supplementary music curriculum designed to promote the development of self-regulatory skills for children facing economic hardship.

Results suggested a positive impact of the focal music intervention on children's development of inhibitory control. In this study, a sample of children who received the music intervention were compared to a demographically matched sample of children who received programming as usual. Those who received the music intervention showed statistically greater growth in inhibitory control across the preschool year. These results support the key study hypothesis and suggest that the music intervention was associated with enhanced self-regulatory growth. The findings are broadly consistent with results of early childhood intervention studies that have found positive effects of certain intervention programs on young children's self-regulatory development (Blair & Raver, 2015), and are specifically aligned with past empirical studies suggesting enhanced self-regulatory development associated with participation in particular music programs (Brown & Sax, 2013; Lobo & Winsler, 2006; Winsler et al., 2011). The present results highlight the potential for using early childhood music not only for the sake of music itself (Eisner, 1998), but also to support growth in a critical aspect of school readiness.

The music program investigated in the present study was somewhat unique. Whereas several robust studies have focused on the impact of discrete music and arts classes, for example, the present intervention involved a visiting artist teacher who led the preschool class in discrete music activities as well as demonstrated for the early childhood teacher how to integrate music into the classroom more broadly, using songs to facilitate smooth transi-

tions between activities, for example, or to help children through social-emotional challenges that arose.

The positive effects associated with the present model are of interest. An artist teacher who trains the early childhood teacher in music integration may be uniquely beneficial given that early childhood teachers report feeling underprepared to integrate music (Nardo et al., 2006). Barrett et al. (2019) study demonstrated qualitative benefits of music teachers mentoring of early childhood teachers, and teacher training has been a central component of well studied non-music interventions, such as the CSRP (Raver et al., 2009; 2011). Whereas some prior, quasi-experimental studies have focused on an intensive model in which children receive music classes multiple times each day (e.g., Brown & Sax, 2013), the focal model for the present study involved music teacher visits just 24 times across the preschool year for two hours per session. This might be a cost effective, scalable model for promoting self-regulatory development as well as providing high quality music programming for children who otherwise might not have access. The present results suggest that even this relatively small dose of this type of music programming added value to what was already considered high quality preschool.

The present study adds to evidence that the benefits of music programming for young children's self-regulation may not be apparent immediately upon beginning a music program, but rather may emerge across time and accumulated exposure. Brown et al. (2017) study, for example, demonstrated that child stress levels were lower after music and arts classes, yet not at the start of the year. Rather, effects emerged midyear and were maintained at year's end. A similar pattern was evident in the present study, as statistical differences in inhibitory control for children who received the music intervention compared with programming as usual were apparent only at the mid- and end-of-year time points. These findings suggest that the demonstrated benefits reflected more than the short-term effect of children listening to a calming song, for example, and may have depended at least in part on children's ability to develop and practice self-regulatory skills. Although the present study did not probe mechanisms of effect, the proposition that benefits emerge as children practice certain self-regulatory skills is consistent with Winsler et al. (2011) findings that, compared to a control group, young children who participated in a music and movement program showed higher levels of self-talk and were more likely to use strategies such as humming to aid behavioral and emotional regulation.

The present study controlled for key demographic variables as well as receptive vocabulary. Consistent with expectations, older preschool children showed greater self-regulation. Notably, they also showed less growth across the year, perhaps due to "ceiling effects" or the fact that, by midyear, some older children obtained the maximum scores possible on certain measures of inhibitory control. Also consistent with expectations, children who had higher start-of-year receptive vocabulary showed higher inhibitory control and less growth across the year. Furthermore, as anticipated, the covariates that stood as proxies for poverty and racism predicted lower inhibitory control. The findings are consistent with a robust research literature linking poverty risks to difficulties with self-regulation and suggest that varying levels of family income impoverishment may map onto differences in inhibitory control even within a sample facing economic hardship (Blair & Raver, 2012). The findings also add to evidence that there are risks associated with racism beyond its economic impact. Structural aspects of racism such as neighborhood violence as well as interpersonal aspects such as microaggressions may tax physiological systems that respond to stress (Peterson et al., 2020) and compromise children's self-regulatory development (Brown et al., 2019). The present findings underscore the importance of interventions that promote self-regulatory development for young children facing risks related to poverty and racism.

7.1. Limitations and future directions

Several limitations of the present research deserve mention. First, results showing a self-regulatory advantage linked to early childhood music are specific to MacPhail Center for Music's Learning with Music Program, through Sing, Play, Learn with Macphail. This program was selected for study in part due to its unique model. Whereas several past, robust studies of early childhood music and movement in relation to self-regulatory outcomes have focused on the impact of music or music and movement classes (e.g., Brown & Sax, 2013; Lobo & Winsler, 2006), the MacPhail model focused on visiting artist teachers who modeled for regular early childhood teachers how to integrate music with specific goals of supporting children's self-regulation. This could meet a demonstrated need for more music training for early childhood teachers (Nardo et al., 2006) and provide a cost-effective alternative to resident artist teachers facilitating access to music education for children facing economic hardship (Barrett et al., 2019). Yet to the extent that MacPhail's Learning with Music Program model is unique, the generalizability of results to other early childhood music programs is limited. Future studies might examine artist-in-residence programs, as well as models with greater family involvement, such as South Africa's MusicWorks (2018), which includes home visits that allow program staff and parents to exchange musical activity ideas.

Second, and on a related note, the present study was designed as an initial test of MacPhail's Learning with Music Program and suggested a self-regulatory advantage associated with its implementation but did not identify mechanisms of effect or active ingredients. Future studies might focus on potential mechanisms such as increased use of self-regulatory private speech, which could be facilitated by teachers' use of music to sing children through emotionally challenging situations. Winsler et al. (2011) study suggested that Kindermusik may boost young children's self-regulation by increasing their use of private speech.

Future research also might test possible active ingredients like teacher modeling of self-regulation and provision of creative or expressive outlets, which represent a focus of many music therapy programs, such as Save the Children's HEART (Healing and Education Through the Arts) which operates across 22 countries in Asia, Africa, the Middle East, Eastern Europe, and Latin America. Future studies might manipulate music program components as well as study different populations to better understand what types of programming would most benefit the self-regulatory development of children in different circumstances. HEART, for example, is designed to address effects of absolute poverty, war, and trauma (Save the Children, 2021), which could pose challenges to emotion regulation different from those associated with economic hardship in the US. A fuller understanding of the opportunities for using music to promote self-regulation will require studying children with greater diversity in terms of factors such as age and socioeconomic status, racial, ethnic, and linguistic background, geographic location, trauma history, and ability or disability status.

Third, the present study suffers from the typical limitations of quasi-experimental designs. The selection of preschool programs that were matched on multiple aspects of quality and curricula was a strength, as was the combination of within- and between-preschool comparisons to examine the impact of the music intervention. Still, without random assignment to MacPhail's Learning with Music Program versus programming as usual, we cannot rule out the possibility that positive results for the Music Program were

driven by some combination of preschool characteristics and cohort effects. Indeed, findings of statistical differences by preschool type highlight this possibility. One of the preschools had received the Music Program for 9 years before the start of the present study, and although key findings were similar with or without the inclusion of this preschool, study design did not allow us to fully investigate the impact of classroom teachers' years of training in Learning with Music or effective implementation of targeted music strategies, or to disentangle these from certain other aspects of program quality that may have co-varied. Neither did variables included in the present study elucidate reasons for low enrollment at the third preschool, which resulted in a decision to include a fourth preschool in the study for the second and third years. The fact that this fourth preschool was not studied during the first year is another limitation. Additionally, although a growing body of evidence suggests self-regulatory benefits of early childhood music programs (Menzer, 2015), it is possible that effects demonstrated in the present study related an aspect of the Music Program beyond music itself, such as the presence of another supportive adult in the classroom during music sessions. The fact this adult visited infrequently reduces but does not eliminate this possibility.

Controls for several child demographic variables reduced but did not eliminate the possibility that selection effects or unmeasured child characteristics contributed to results. As is the case with most preschools serving families at risk due to poverty, preschool directors indicated that most families lived nearby and had selected the program due to geographic proximity to their place of residence. Yet the preschools did have some differences beyond their street address that may have led families to select one over another, and, if preschools touted their receipt of the MacPhail Learning with Music Program as a strength of their program, this could have been a factor that influenced school choice. An additional example of an unmeasured child characteristic is years of early childhood program attendance, which may have influenced results.

True experimental designs with random assignment would be important for disentangling potential benefits of the arts from other factors that influence educational outcomes. Lobo and Winsler's (2006) study provided an important example of how such designs might be used to study music and movement programming. In the Lobo and Winsler study, children attending Head Start were randomly assigned to an experimental dance program versus attention control group. In the absence of such robust experimental designs, future studies should include additional controls for sample and program characteristics and further pre- versus post-program comparisons to pinpoint the value added by certain types of music experiences. Furthermore, although the research assistant was not made aware of study hypotheses, there is a possible influence of researcher bias. Future research would benefit from multiple raters and additional methods of measurement for key self-regulatory constructs. Also, longer-term studies would be useful, particularly if they spanned across the transition to formal schooling. Such investigations would shed light on the extent to which early childhood music programming might influence children's self-regulatory and academic outcomes in elementary school.

8. Conclusion

The present study investigated a unique model of early childhood music programming in relation to self-regulation for children at risk via economic hardship. Past research has demonstrated the potential for early childhood music and movement programming to contribute to self-regulatory growth for children facing poverty risks (Brown & Sax, 2013; Lobo & Winsler, 2006). Yet whereas past research has studied the impact of music and movement classes, the MacPhail Learning with Music Program involved a visiting teacher who modeled for early childhood teachers how to integrate music into the classroom with goals of promoting children's self-regulation. The present study indicated an advantage of this program for children's growth in self-regulation across a year of preschool attendance.

Self-regulation undergirds academic and social-emotional success (Raver & Knitzer, 2002), and may be particularly important for children in poverty who face disproportionate challenges (Yoshikawa et al., 2012). Yet the poverty risks that pose challenges also undermine self-regulatory skill development, which raises the bar for the preschool programs that serve children facing economic hardship (Blair & Raver, 2015). The present study adds to a body of evidence suggesting that high quality interventions can promote self-regulatory development across a year of preschool attendance (Blair & Raver, 2015), and suggests the efficacy of certain types of early childhood music programming (Menzer, 2015). Implications concern the potential for early childhood music programming to promote self-regulatory skill development and equip children to thrive in the face of challenges posed by economic hardship.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ecresq.2022.01.002.

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