Proposal for the program on
"Valuation of ecosystem services provided by birdsong in music education"

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Abstract: The sound of pleasant birdsong has long been associated with our own happiness and relaxation. In concert with general outdoor experiences, the effects of familiar birdsong also appear to promote a sense of safety that may be linked to our perceived correlation of songbirds with good habitat. Additionally, the musicality of birdsong is reflected in our understanding and appreciation of our own music. Knowing that outdoor experiential learning is correlated to human cognitive improvements and well-being, there is a potential benefit of linking birdsong directly to music and ecology education. Through acute and purposeful listening, the study of birdsong may result in an improved ability to hear tonal changes and reproduce tonal sequences in acoustically layered environments, particularly in young children who have not yet had extensive western musical training. Additionally, the benefits to students hearing these learned birdsongs outside may contribute to a heightened sense of happiness, safety and well-being compared to those who hear no birdsong or are not trained to recognize it.

Introduction: The contribution to ecosystem services by birds includes effects of both bird behavior and bird products, spanning across the four types of services (supporting, provisioning, regulating, and cultural) recognized in the UN Millennium Ecosystem Assessment (2005). Worldwide, birds fulfill ecosystem niches as pollinators, scavengers, predators, seed dispersers, insect pest controllers, and food sources (Sekercioglu, 2006; Whelan, Wenny & Marquis, 2008). Additionally, the popular pastime of birding provides happiness and recreation to people worldwide while also generating revenue through travel costs, eco-tours, and sales of equipment such as books and binoculars.

Birdsong itself provides an important cultural ecosystem service to those who listen, increasing their well-being through abstract listening in home or work environments, or during intentional birding excursions (Fuller et al., 2007; Luck et al., 2011). Research suggests that both the site and sound of birds improve general mental health, including increased attention restoration, creative thinking and ability to complete tasks (Ratcliffe, 2013). Specifically, interwoven birdsong of multiple species may be an important facet of bird enjoyment (Hedblom et al., 2014) due to the increased perception of, and benefits from, biodiversity in these areas (Dallimer et al., 2012).

Given the breadth of prior research concerning the positive effects of nature exposure on humans[1], the connection of birdsong to increased happiness is not

[1] Ulrich's (1983) stress recovery theory (SRT) connected the benefit that humans derive from natural environments to the reduction in the effects of a prior stressor.

surprising. However, recent research has also linked the soundscape of local birdsong to feelings of comfort and safety (Alvarson, Wien & Nilsson, 2010; Berman, Jonides & Kaplan, 2008**;** Ratcliffe, 2013). Humans can hear sounds between the frequencies of 20 hertz (a low pitch) to 20 kilohertz (a high pitch), but our hearing is most acute between 2.5 to 5 kilohertz. Although it has long been thought that human hearing evolved to hear the human voice (Bidelman, Gandour & Krishan, 2011), the frequency of human voice falls below this discreet bandwidth of sensitive human hearing (Heather, 2014). The songs of passerine birds, however, match this bandwidth well, which has led acoustic ecologist Gordon Hempton to hypothesize that humans evolved to hear birdsong that indicated good habitat and warned of danger (Hempton, 2014).

Additionally, a study conducted with individuals who moved from Australia to the United Kingdom, and vice versa, recorded the amount of unease that participants felt when their birdsong soundscape changed as a result of moving to a new suite of bird species. The authors ultimately suggested that the presence of recognizable birds and their songs permeate a sense of safety (Whitehouse, 2009). And although pre-recorded birdsong is thought to improve human experiences when inside, particularly in potentially stressful locations such as hospitals, doctors' offices, or airports (BBC News, 2013), research suggests that humans gain the most restorative effects of natural sights and sounds when viewed and heard outdoors in nature (Kjellgren & Buhrkall, 2010).

Teachers of school-age children are increasingly encouraged to capitalize on the restorative effects of outdoor education (Association of Fish & Wildlife Agencies, 2011; Wagner & Gordon, 2010). However, few curricula connect the academic rigor of science and ecology classes to the increased well-being derived from the outdoor experience; fewer still connect other disciplines such as English, art or music to outdoor learning experiences. Birdsong may provide a natural connection between music education and the increased well-being derived from being outdoors and listening to birdsong (Milius, 2000; Younker & Bracken, 2014). The contribution of birdsong influence on music composition, understanding and enjoyment has been well-recognized in popular culture but is not well understood within the scientific literature.

Problem Statement: Educational curriculum promoting music education through birdsong is sparse (Silverman et al., 2007, Younker and Bracken, 2014), and no studies have quantified the educational benefits of integrating birdsong and its related ecology into music education. This project proposes that birds, specifically birdsong, may offer a service to school systems looking to improve or diversify the way in which music is taught, particularly in conjunction with ecology curriculum. Previous research on the positive effects of tonal languages on musicality (Bidelman, Hutka & Moreno, 2013) may suggest that tonal exposure in varied ways (here, in

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Morton (1977) documented how smoothness, intensity and pitch associated with animal sounds are related to the presence or absence of threats.

birdsong) promotes acute listening and pitch perception that ultimately improves and broadens musical comprehension. Although students may need recordings or modified sheet music to learn individual birdsongs in isolation of each other, we hypothesize that students who listen for and practice these bird songs outside as part of an integrated music and ecology education will feel greater happiness and connection to their landscape than students who learn music without recognizing a connection to birdsong and bird ecology.

Project Description: This project will compare two groups of students in grades three through five who have some previous exposure to musical terminology and a minimum proficiency in voice or instrument training. The project will evaluate two hypotheses:

Birdsongs may provide an educational ecosystem service that benefits students' musical aptitude and tonal growth. Although the contrasting curriculums integral to this project are short, we hypothesize that students learning birdsong in music class exhibit a greater proficiency in music, namely in pitch recognition and discrimination, repeating complex tonal sequences, identification of musical form and ability to focus on musical phrases layered within other sounds.

Birdsongs may provide an educational service that benefits students' well-being. Compared to students who learn music in a traditional setting, students that learn local birdsongs in music education (whether with their voice or on an instrument) and practice recognizing these calls outside ultimately feel greater happiness, an increased sense of safety, and experience greater connection to their local environment. Additionally, these students will experience less anxiety and greater recovery from stress after time spent outside with these birds compared to students who have musical training but did not learn and emulate birdsongs.

To evaluate the variable of birdsong within music education, this study will examine two study groups of between 10 and 15 students. Group A will complete a 12-unit integrated birdsong curriculum modeled on the curriculum developed by Silverman et al. (2007), but with further emphasis placed on tonal reproduction of ten local birdsongs. Students will also study the habitat requirements and behavior of birds, particularly when related to their songs, by observing birds outside during the early morning and evening when birds are most active. They will complete field logs and answer directed questions modeled from Silverman et al., these may include: How are the sounds of a cardinal's song different from its call? When does a bird sing? How can a bird communicate without drawing attention to itself?

Group B will follow a 12-unit music course that achieves music education goals outlined in the Content Standards for Vermont (Vermont State Board of Education, 2004) for grades three through five. This curriculum will include interval training, pattern and rhythm recognition, and error-detection in pitches. In parallel, this group will spend time outdoors; however, no emphasis will be placed on birdsong

and students will be outside during the mid-day in locations where birds are not most active.

Intermediate Services	Final Services	Benefits
Birdsong	Music Education	• Tonal Development • Increased Melodic Recognition Abilities
	Sense of security and happiness in a place	• Increased ability to focus on outdoor experience and "let go" of stressors • Positive sense of connection to their local environment • Reduced anxiety after a stressful event.

Table 1 Relationship between intermediate and final services provided by birdsong and their benefits to humans.

The success of birdsong education will be evaluated in two ways:

A quantitative assessment through age-appropriate testing that evaluates students' abilities to remember, repeat and discern differences among musical pitch and phrases. Both before and after following the 12-unit education curriculum, students will be asked to discern tonal differences in melodies in intervals of half-tones[2], quarter-tones and less than quarter-tones. Pitch perception measurements will focus on three aspects of tonal musicality previously identified in Bidelman, Hutka & Moreno (2013) – pitch processing speed, pitch memory and melody discrimination. The study will also assess ability to perform melodic reproduction and level of musical focus and ability.

Tested Skill	**To test, students will:**	**Students demonstrate higher proficiency if they can correctly:**
Pitch processing speed	listen to a two-tone warble and identify whether the second tone was higher or lower in pitch than the first (Fig 1a)	identify pitch changes as warble speed increases and the interval of pitch differences decreases
Pitch memory	listen to a pitch in isolation, then a passage of four separate notes (Fig 1b)	identify whether or not the initial pitch was included, and identify target pitches within small interval ranges
Melody discrimination	listen to two four- to eight-note melodies that are either	identify outlying pitches of decreasing pitch intervals

[2] A half-tone interval is the smallest interval in the 12-tone western music scale, or the pitch difference between two immediately adjacent keys on a piano. A quarter-tone interval is one-half of a half-tone interval.

	identical or differ by one note (Fig 1c)	
Melody reproduction	listen to a melodic phrase and reproduce it with either their voice or on their instrument	replicate more rhythmically and tonally complex passages, including intervals that fall outside of the 12-tone western music scale
Musical focus	listen to a single musical phrase of between three and five notes and identify if that phrase is within a series of overlain musical phrases of similar length	identify whether or not the phrase was included as more phrases are added.

Table 2 Five tests will be used in this study to evaluate students' tonal abilities.

A qualitative assessment performed through interviews and survey questions that document both stated and revealed preferences concerning birdsong enjoyment and familiarity. In order to assess the relationship between live birdsong and stress recovery, the students will participate in an age-appropriate situation that creates some social or academic stress (e.g. a focused test, a debate). This will be followed by time spent outdoors where they can experience sights, sounds and smells of their local environment. Students in Group A will be exposed to ample birdsong during the morning hours; those in Group B will be outside when and where there is little exposure to birdsong (e.g. a courtyard during mid-day). To ensure that students have the opportunity to separate from their peers and listen to their surroundings as they choose, the study will be conducted in sub-groups of three to five students.

Students will also complete a semi-structured interview focusing on the relation of their experience outdoors and their personal attention restoration and stress recovery. Questions will be modeled after Ratcliffe, Gatersleben & Snowden, (2013) who interviewed participants to examine the details of sound their (the interviewees') ideal restorative environments. Questions may include:

How did your time outside make you feel?
What about your time outside made you feel that way?
What were you touching, seeing or hearing on your walk?
Was there anything unpleasant about your time outside? What, and why?
What could have happened outside that would have made you happier?
What could have happened outside that would have made you feel safer?

Understanding that these students are young, questions will be simple and playful. Interviews will last no more than 10 minutes. Interview transcripts will be analyzed to identify key themes related to attention restoration theory (ART: Kaplan & Kaplan, 1989) and stress recovery theory (SRT: Ulrich, 1983), including:

a) affective appraisals, which link the identification of pleasant birdsong to restoration from mental fatigue or stress, focusing on feelings of happiness and safety,

b) cognitive appraisals, which link a student's focus on birdsong to disassociation to the previous stressor; and,

c) relationship with nature, which identifies the level to which students can feel a connection to nature and the restorative potential of bird (non-human) company.

Expected Outcomes and Products: This study will result in the publication of three peer-reviewed articles; the first will focus on the tonal ability of birdsong learners, the second on the increased sense of place felt by those who study birdsong and the metrics which may measure it, and the third on the ability of birdsong learners to listen with more focus in acoustically complex environments.

The study will also pilot a birdsong-based music curriculum and make it publically available after testing and revision. The curriculum will focus on the third to fifth grade learning levels but will make suggestions for both older and younger students. As a result of the pilot curriculum, a birdsong CD will be made available that includes songs and calls divided into levels of musical difficulty for student learning.

Significance: The beneficial use of birdsong as an educational tool will provide educators with place-based material that not only improves students' tonal growth, but also their ability to learn in integrated and unpredictable settings. Teachers may find benefit in learning how to create successful learning outcomes while working in the "messiness" typical of outdoor education. An integrated birdsong and music curriculum also promotes appreciation and enjoyment of local birds and their environments through purposeful observation.

The value of such services may be measured by any monetary savings achieved by integrating music lessons into other curriculum, through the increased proficiency of students who follow such a curriculum, through a transfer of increased cognitive ability in music to other disciplines, or through the reduction of resources needed to help students alleviate anxiety, stress or feelings of isolation. Internal appreciation of birdsong (that is, the ability to understand its musicality, recreate it, and relate it to observation) may also benefit bird habitat conservation efforts, particularly those that promote multiple species and biodiversity. This benefit will become increasingly valuable as more population moves to urban areas where bird habitat will need to be designed, built and nurtured. Furthermore, the effect of in-situ bird study, as opposed to birdsong identification and replication via books and recordings, may promote future studies that examine the learning enhancement that exists when people relate sounds to image and lived experiences.

Budget: Table 3 shows the budget for each year by line item.

Personnel costs: The majority of the project's total costs will come from supporting a professor for project guidance, a graduate student for two years, and two research assistants who will help interview the students before and during the 12-unit study sessions and research field conditions (birds present, note site-specific conditions). The graduate student will be funded for 20 hours per week for the duration of the project. Research assistants will be paid $12 per hour for approximately 150 hours of work each. The academic advisor will provide guidance for the equivalent of one month per year. The study assumes participation of a teacher in a local established school system who will already be compensated by the school.

Other costs: The remaining portion of the budget will fund equipment necessary to create and play the tonal and melodic tests, and to record interviews. Professional transcription will be necessary before analyzing interviews for key themes. The study assumes small travel costs to local schools.

	Year 1	Year 2	**Total**
Graduate Student	$30,000	$30,000	$60,000
Professor (1 months/year)	$5,800	$5,800	$11,600
Research Assistants	$4,000	$0	$4,000
Transcription	$450	$0	$450
Printing, audio equipment	$1,000	$1,000	$2,000
Travel	$500	$0	$500
Overhead (25%)	$10,437	$9,200	$19,637
Total			**$98,187**

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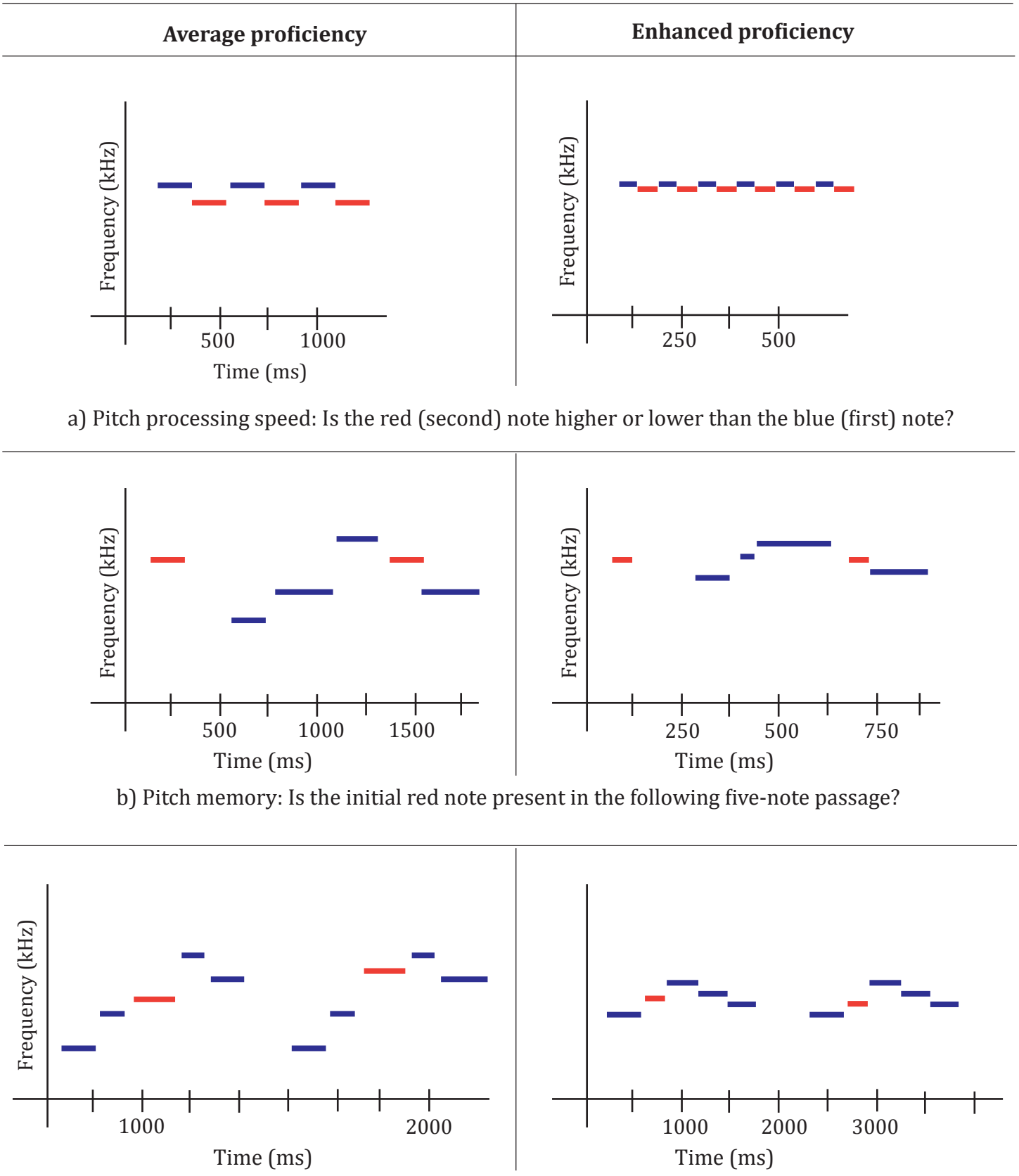

Figure 1: Rendering of three of the five tests used to quantitatively assess tonal ability and musical phrase recogntion.