The theory, practice, and measurement of Music Therapy

Developing evidence from diverse practice

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SMPC|2013

The biennial meeting of the Society for Music Perception and Cognition

CONFERENCE PROGRAM

Edited by Michael Schutz and Frank A. Russo

RYERSON UNIVERSITY

Toronto, Canada
August 8-11, 2013

SMPC|2013
The biennial meeting of the Society for Music Perception and Cognition

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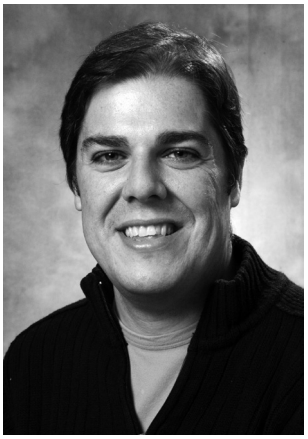

It is my sincere pleasure to welcome you to Toronto, Ryerson, and the 2013 Meeting of the Society for Music Perception and Cognition. Toronto is a natural choice for hosting SMPC, given the high concentration of labs and research facilities in the area devoted to the study of music cognition. With over 300 delegates registered and hailing from across the globe, this stands to be the largest and most diverse meeting held by the Society to date.

The unprecedented interest in this year's meeting necessitated a move to four parallel tracks. We have attempted to facilitate movement between tracks through central time keeping and by housing all presentations in a single conference building, the George Vari Engineering and Computing Centre, located at 245 Church Street. In addition we have asked session chairs to be extra diligent about their time-keeping responsibilities. The only session scheduled outside the main conference building is the Early Career Session, which will take place on Friday evening in the Thomas Lounge of the Oakham House, located directly across from the main building at the southwest corner of Church and Gould Streets.

On the inside front cover of this book, please find four trifold inserts, one for each day of the meeting. Each insert provides an orientation map and a convenient overview of sessions that will help you plan your day and navigate between tracks. If you have any questions about the conference, please check with the registration desk on the ground level of the main conference building. Local hosts will be stationed there at all times.

In addition to the abundant scholarly offerings at this meeting, we hope you will take the opportunity to connect with colleagues at lunch, coffee breaks, and the social gatherings we have planned. In particular, we hope you will consider joining us for our Welcome Reception in the University Quad and our banquet cruise of the Toronto Harbour, scheduled on Thursday and Saturday evenings, respectively.

I would be remiss if I did not acknowledge the many contributions made by members of the Society in making this meeting possible. The program committee, program logistics committee, scientific advisory board, awards committee, and local organizing committee have all contributed countless hours. I would also like to acknowledge the generous funding support we have received. This includes seed funding from Ryerson's department of Psychology and the Faculty of Arts, as well as corporate funding from Martin Guitar and Phonak AG.

Welcome!

Frank Russo
Conference Chair
Ryerson University

Welcoming Address by Program Chair

I am pleased and excited to welcome you to SMPC 2013! Our members' dedication to research has driven significant growth in the Society since our first meeting in 1992. Consequently, this year's program features a broad array of topics organized into 48 thematic sessions within 11 subject areas, ranging from Music & Language (4 sessions) to Computational Approaches (4 sessions); Education (5 sessions) to Neuroscience (5 sessions).

We will also host two symposia touching on key issues of broad significance to our research field. The first: *Theory, Practice, and Measurement of Music Therapy* (3A-3; Saturday morning) highlights connections between cognition and therapy. The second: *Good Data Practices and Reliability* (3A-4; Saturday morning) builds upon discussion within the broader scientific community regarding best research practices. Recognizing the critical importance of professional development, we are hosting a special roundtable on the *Challenges and Opportunities of Teaching and Research at Primarily Undergraduate Institutions* (3C-4; Saturday afternoon), as well as a discussion on *The Academic Job Search* (Friday evening) geared in particular towards early career researchers. As in the past, we will also offer student-faculty lunch pairings encouraging informal dialogue and networking.

Acknowledging the complexity inherent in moving between four parallel tracks, we have adopted an abstract numbering system in which each ID indicates presentation time and location. Therefore the talk *Consonance and dissonance perception in infants* (1A-1.1) occurs on the first day—Thursday (1) within the first block (A) and is part of the first track where it is the first talk (1.1). Similarly, *Cognitive benefits of music and art training in healthy older adults* (1B-4.3) takes place in Thursday's second block (1B), within the fourth track where it is the third talk (4.3). Posters are enumerated within each day: 1-05 refers to Thursday's fifth poster; 3-12 to Saturday's twelfth; etc. (see page 12 for further explanation).

My goal in structuring the program has been to highlight questions and techniques of broad interest, and I am sure you will share my excitement each day when looking over the schedule. From our keynote by 2011 SMPC Achievement Award winner Dr. Carol Krumhansl to our first-ever "public lecture" by Dr. Daniel Levitin encouraging interest among the general public to the 284 scheduled presentations of new research, this meeting promises to be informative, fascinating, and entertaining.

Welcome!

Michael Schutz
Chair, SMPC 2013 Programming Committee
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Sponsors

SMPC'13 is supported in part by seed funding provided by the Faculty of Arts and the Department of Psychology, Ryerson University. Grand prizes in the student paper competition are funded by Phonak AG and Martin Guitar. The public lecture is funded by Phonak AG.

Special Events Timetable

SMPC Special Events

Wednesday, August 7	5:00-8:00 pm	Registration Desk Opens, ENG Ground Floor
Thursday, August 8	8:30 am	Welcome Address, ENG103
	6:00-8:30 pm	Welcome Reception, University Quad
Friday, August 9	4.20-6.20 pm	President's Address, Lifetime Achievement, Keynote, ENG 103
	7:30-8:30 pm	Early Career Session, Thomas Lounge, Oakham House
Saturday, August 10	11:40-12:40 pm	Business Meeting and Student Awards, ENG 103
	6:20-10:30 pm	Banquet Cruise
		(buses depart from Gould at 6.20 pm; boarding at 6.45 pm)
Sunday, August 11	12:00-12:10 pm	Closing Remarks, ENG103
	1:00-2:30 pm	Public Lecture, ENG103

Other Special Events

Wednesday, August 7	9:am-6:pm	CogMIR, Ryerson
	6:30-10:00 pm	Live Lab Tour
		(buses depart from Gould at 6.30 pm; tour starts at 7.30 pm), MIMM
Sunday, August 11	3:00-5:00 pm	AIRS Open Poster Session (no registration required), Atrium
Sunday, August 11- Tuesday, August13		Auditory Cognitive Neuroscience Workshop, MIMM
Sunday, August 11- Tuesday, August13		AIRS Annual Meeting, Ryerson

Student Awards

SMPC
Society for Music
Perception and Cognition

The following is an alphabetically ordered list of undergraduate students, graduate students, and post-doctoral fellows who were selected to receive a student award. The awards committee based its adjudication on two-page expanded versions of the submitted conference abstract.

Eight of the awards are valued at $250 each and sponsored by SMPC. The remaining two awards, considered Grand Prizes, are valued at $500 each and sponsored by industry: ***Phonak AG*** and ***Martin Guitar***. Formal presentation of the awards, including the announcement of Grand Prize winners, will be made at the business meeting.

Jenine L. Brown, Eastman School of Music [Graduate Student]
Daniel Cameron, Brain and Mind Institute, Western University [Graduate Student]
Georgia-Aristi Floridou, Department of Psychology, Goldsmiths College, University of London [Graduate Student]
Elisa Kim Fromboluti, Department of Psychology, Michigan State University [Graduate Student]
Michael Hove, Harvard Medical School [Post-Doctoral Fellow]
Mats Küssner, Department of Music, King's College London [Graduate Student]
Brandon T. Paul, Department of Speech and Hearing Science, The Ohio State University [Graduate Student]
Richard Warren, Purchase College, State University of New York [Undergraduate Student]
Elizabeth Ann Wieland, Communicative Sciences and Disorders Department, Michigan State University [Graduate Student]
Patrycja A. Zdziarska, Department of Psychology, Michigan State University [Undergraduate Student]

Presentation Guidelines

Oral presentation guidelines:

Because we will be proceeding with four parallel tracks it is important that all presenters keep to the designated 20 minute time limit, which should be structured as 15 minutes for presentations, three minutes for questions, and two minutes for change-over to the next presenter. Presenters are invited to try their presentations before their session begins. A technical assistant will be available during the 15 minutes leading up to each session and will be on hand throughout the session to assist with any technical difficulties that may arise. However, the planned timing will be adhered to regardless of technical difficulties.

Session chairs will use colored paddles to provide five-minute and two-minutes warnings prior to the end of the allotted 15-minute presentation time. All rooms will come equipped with a master clock that will sit at the podium facing the audience. Please consider synchronizing your time-keeping device to the master clock before your presentation.

The podium computer will support PPT, PPTX, PDF, DOC, DOCX and HTML files. If you intend to use the podium computer, please bring your presentation files on a standard USB memory stick. If you intend to use your own laptop or tablet, please note that the podium will accept VGA or Mini DVI connectors for video and 1/8" miniplug for audio. All rooms are equipped with built-in speakers. A touch screen on the podium panel may be used to control the master volume.

Poster presentation guidelines:

Posters must be printed in portrait orientation with the following dimensions:
3 feet (wide) x 4 feet (tall).

Portrait

Posters will be displayed in the Atrium. The Atrium will be opened at 8 AM each morning and will remain open during breaks and over the lunch hours. At least one author must be present at the poster during the assigned presentation time. Presenters are encouraged to set posters up prior to the first session on the day they are presenting.

Keynote and Public Lecture

Dr. Carol Lynne Krumhansl

Dr. Krumhansl is a Professor of Psychology and a member of the graduate fields of Music and Cognitive Science at Cornell University. The Music Cognition Laboratory, founded in 1980, has studied a wide range of topics. The experiments on tonality, pitch, and harmony helped establish the psychological reality of music-theoretic concepts. Contemporary proposals on melodic structure and musical tension have been tested and extended to music from other cultures and post-tonal music. Other research topics include rhythm and meter, perception of time, perceptual-motor synchronization, timbre, musical development, emotional responses, and multi-modal evaluations of musical performances. Recent and current research is using popular music and film to study memory representations and associated autobiographical memories.

Dr. Krumhansl is the author of Cognitive Foundations of Musical Pitch in addition to numerous journal articles. She has held visiting appointments at the Center for Advanced Study in the Behavioral Sciences, IRCAM, Montreal Neurological Institute, McGill University, UCSD, and the University of Jyväskylä, which awarded her an honorary doctorate in musicology. She is past-president of SMPC and the 2011 recipient of the SMPC Achievement Award. Dr. Krumhansl has been elected Fellow of the Association for Psychological Science, the Society of Experimental Psychologists, and the American Academy of Arts & Sciences.

Her **keynote** is titled "Musical Tension: Statistics, Structure, and Style."
Friday, August 9th, 4:20 pm Room ENG 103

Dr. Daniel J. Levitin

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Dr. Levitin is the James McGill Professor of Psychology and Neuroscience at McGill University. He holds Associate Appointments in the School of Computer Science, Faculty of Education, Department of Neurology & Neurosurgery, and School of Music. He earned his Ph.D. in Cognitive Psychology at the University of Oregon, his B.A. from Stanford in Cognitive Psychology, and completed post-doctoral training at Stanford University Medical School and UC Berkeley. He has been a visiting professor at Stanford University, UC Berkeley and Dartmouth.

Levitin is the author of the book "This Is Your Brain On Music" which remained on The New York Times and The Globe and Mail bestseller lists for more than 16 months and was named among the Top 20 books of 2006 by The Globe and Mail. "The World in Six Songs: How the Musical Brain Created Human Nature" debuted on The New York Times list, reached #1 on The Globe and Mail bestseller list, and was named one of the best books of the year by the Boston Herald and Seed mazine. He has published more than 100 scientific articles, and over 300 popular articles about music and music technology in magazines including Billboard, Electronic Musician, Mix, and Grammy. His research has been featured on the MacNeil/Lehrer NewsHour, The New York Times, The London Times, Scientific American, and Rolling Stone. He is also a frequent guest on NPR and CBC Radio.

His **public lecture** will discuss three broad questions from the cognitive neuroscience of music: Why we like the music we like, how people become musical experts, and what areas of the brain are activated by music.
Sunday, August 11th, 1 pm Room ENG 103

THURSDAY	Track 1 [ENG 101]	Track 2 [ENG 103]	Track 3 [LG 14]	Track 4 [LG 11]
9:00 - 10:20	Perception 1: Tonality & Consonance	Rhythm & Beat 1: Body Rhythms	Emotion 1: Influencing Affect	Language 1: Improvements & Enhancements
10:20 - 10:40	coffee break			
10:40 - 12:00	Computational 1: Modeling Music	Emotion 2: Signaling & Communication	Education 1: Singing Abilities	Cognition 1: Learning, Recognition & Transfer
12:00 - 1:40	lunch			
1:40 - 2:40	Perception 2: Pitch & Timbre	Cognition 2: Singing & Song	Computational 2: Corpus Analysis	Social 1: Culture & Trends
2:40 - 4:20	posters - nutrition break - Atrium (3rd Floor)			
4:20 - 5:40	Computational 3: Analysis & Representation	Rhythm & Beat 2: Entrainment & Synchronization	Perception 3: Pitch & Learning	Education 2: Informing Musical Practice
FRIDAY				
8:40 - 10:20	Language 2: Parallels & Improvements	Rhythm & Beat 3: Meter	Perception 4: Autism & Hearing Impairments	Theory/Composition 1: Voice - Leading & Aesthetics
10:20 - 10:40	coffee break			
10:40 - 12:00	Education 3: Teaching Methods & Practice	Neuroscience 1: Memory & Retrieval	Perception 5: Amplitude & Temporal Processing	Theory/Composition 2: Harmonic Context
12:00 - 1:40	lunch			
1:40 - 2:40	Computational 4: Music Information Retrieval	Cognition 3: Earworms & Musical Imagery	Social 2: Cultural Musical Structures & Tuning	Education 4: Musical Schemas & Cues
2:40 - 4:20	posters - nutrition break - Atrium (3rd Floor)			
SATURDAY				
8:40 - 10:20	Neuroscience 2: Effects of Training	Language 3: Diverse Approaches	Symposium: The Practice of Music Therapy (pt I)	Symposium: Data Replication (pt I)
10:20 - 10:40	coffee break			
10:40 - 11:40		Rhythm & Beat 4: Structure & Syntax	Symposium: The Practice of Music Therapy (pt II)	Symposium: Data Replication (pt II)
11:40 - 1:40	business meeting and student awards - ENG 103 - lunch			
1:40 - 2:40		Cognition 4: Evolution	Neuroscience 3: Transcranial Stimulation & Neuromodeling	PUI: Opportunities and challenges
2:40 - 4:20	posters - nutrition break - Atrium (3rd Floor)			
4:20 - 5:40	Theory/Composition 3: Expression & Improvisation	Neuroscience 4: Music Therapy & Cognitive Processing	Emotion 3: Visual Influence	Perception 6: Multimodal Perception
SUNDAY				
8:40 - 10:20	Education 5: Music & Development	Cognition 5: Movement & Dance	Theory/Composition 4: Neurodynamics & Tonality	Perception 7: Beyond The Concert Hall
10:20 - 10:40	coffee break			
10:40 - 12:00	Perception 8: Structure & Time	Emotion 4: Moving Beyond 'Happy' and 'Sad'	Neuroscience 4: Sensorimotor Imaging	Language 4: Transfer Effects

Abstract ID Assignment

Talk naming system:

[day][block]-[track].[slot]

1 = Thursday
2 = Friday
3 = Saturday
4 = Sunday

A = Morning (first)
B = Morning (second)
C = Afternoon (first)
D = Afternoon (second)

1 = Room <ENG 101>
2 = Room <ENG 103>
3 = Room <ENG LG 14>
4 = Room <ENG LG 11>

1 = talk #1
2 = talk #2
3 = talk #3
4 = talk #4
5 = talk #5

Poster naming system:

[day]-[slot]

1 = Thursday
2 = Friday
3 = Saturday

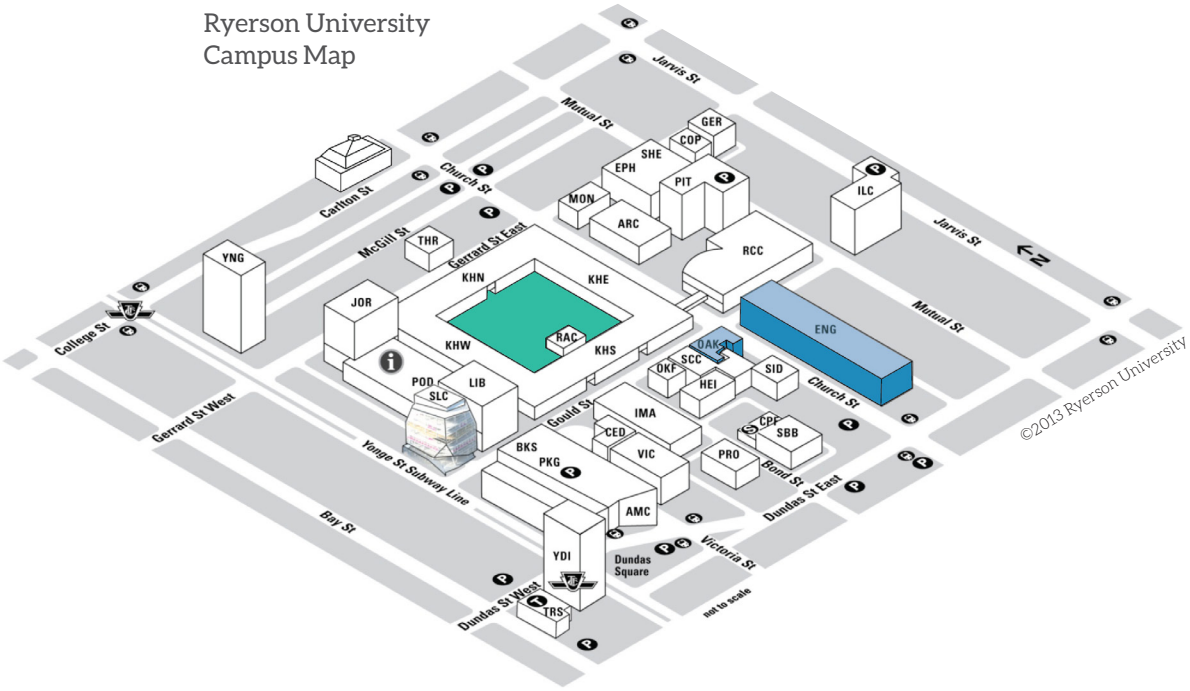
1 = poster #1
2 = poster #2
. . .
34 = poster #34
35 = poster #35

For wifi access:

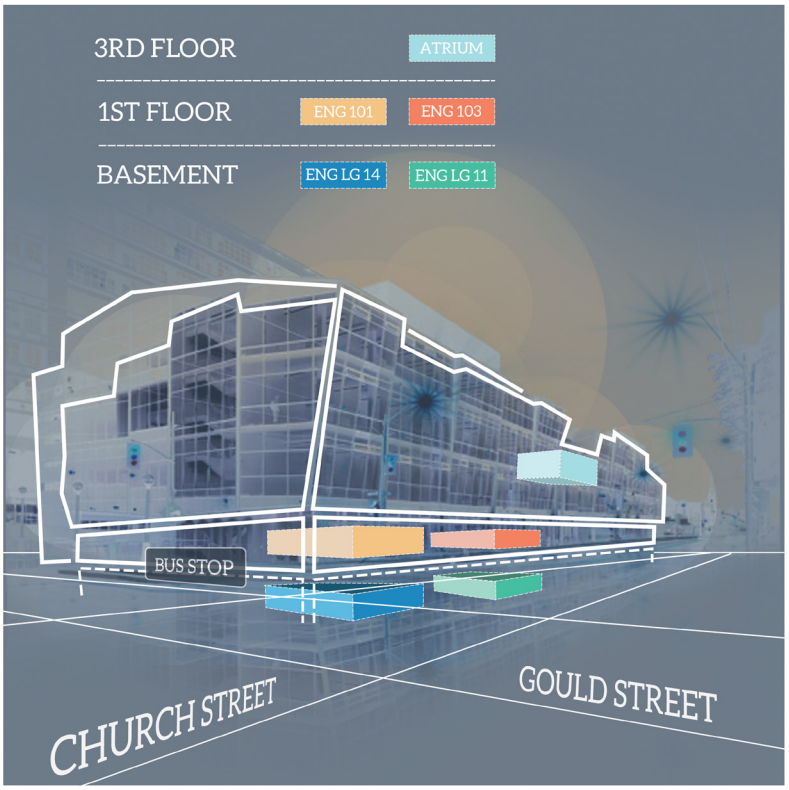
1. Choose either "Ryerson" or "RU-Secure" from your list of available wireless networks.
2. Enter **EGGY1** (case sensitive) as the WEP security key.
3. Open your browser. You will be redirected to the Ryerson login page.
4. Enter **smpc** as your user name and **Ryerson2013** as your password (both case sensitive) and click Log In.

Maps

Ryerson University
Campus Map



Engineering Building (ENG)



Thursday 8 August

Talk Abstracts

[1A-1.1] Consonance and dissonance perception in infants: Critical remarks on recent literature's results and methods

*Nicola Di Stefano**

Institute of Scientific and Technological Activity, University Campus Bio-Medico. Rome, ITALY
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The focus of our investigation is the perception of consonance and dissonance in children. From a theoretical point of view, the nature of consonance and dissonance has been studied in musical history since its beginning. Due to the role played in the construction of the harmonic language, many theorists and composers believed that the definition of these terms was preliminary to any further development of musical syntax.

From a scientific point of view, the ability of perceiving consonance and dissonance has been more and more widely investigated in various subject and through different experimental procedures over the past 20 years. There is a great convergence in terms of results, proving that the ability examined has biological basis.

We reflect on some problematic notions involved in this field of studies, in particular the alternative between biological and acquired, and its role in the definition of the experimental setting. We explain the main difference between an inner approach, such as fMRI, where the experimenter's role is limited, and a behavioral one where the experimenter plays a decisive role. Then we focus on a behavioral approach, the "looking time" method: its origins, use, interpretation and reliability in acoustical perception literature and research.

In conclusion, we introduce a device developed in our University, a "musical cube," which emits different sounds at different degrees of rotation in space. When connected to a PC, it allows us to measure and record the frequency (how many times) and the length of time a baby keeps the toy in a position corresponding to consonance or dissonance sounds. This procedure should give us more direct, simple and raw data, without being invasive or complex–as happens with fMRI–and reducing the experimenter's interpretation with respect to the traditional "looking time method" or "head turn procedure."

[1A-1.2] The psychological representation of trichords in a twelve-tone context

*Jenine L. Brown**

Eastman School of Music - University of Rochester. Rochester, NY, USA
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This study investigates whether listeners implicitly attune to the repetitive adjacent interval patterns found in twelve-tone rows. Specifically, it addresses whether listeners can learn the repetitive trichords (three-note groups) found in derived rows, which contain four versions of one trichordal set-type. Musically-trained listeners were freshmen music majors at the Eastman School of Music and first heard a ~20 minute familiarization phase consisting of the 48 versions of a twelve-tone row. The melody heard during the familiarization phase was presented as a stream of tones similar to that heard in statistical learning studies (e.g., Saffran, Johnson, Aslin, and Newport, 1999). In Experiment 1, listeners (n=10) heard a row created with four trichords, each containing adjacent intervals 1 and 3 (in semitones). In Experiment 2, another group of listeners (n=11) heard a row created with four trichords, each containing adjacent intervals 2 and 5. During the trial phase of both experiments, listeners heard randomly ordered probe-melodic-trichords. Listeners rated trichords on a 1-7 scale, where higher ratings were more idiomatic of the melody heard during the familiarization phase. Listeners rated many types of trichords, including members of all trichordal set-classes. In both experiments, listener ratings significantly correlated with the "Trichord Distribution," which illustrates the number of times each trichord occurred during the familiarization phase. Listeners also rated within-row trichords significantly higher than not-in-row trichords in both Experiments 1 and 2, and more notably, rated common within-row trichords higher than less common within-row trichords. We can conclude that listeners attuned to the intervals occurring between the pitches, rather than the notes themselves. Thus, uninformed listeners were able to implicitly create a hierarchy of more common and less common trichords occurring in a twelve-tone melody, an initial step in aurally understanding a musical genre notoriously difficult to hear.

[1A-1.3] Principal components analysis of the perception of musicality in pitch sequences

*Richard Randall (1,2)**
Adam S. Greenberg (1,3)

(1) Center for the Neural Basis of Cognition, Carnegie Mellon University Pittsburgh, PA, USA,
(2) School of Music, CMU, Pittsburgh, PA, USA
(3) Dept of Psychology, CMU, Pittsburgh, PA, USA
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Musicality can be thought of as a property of sound that emerges when specific organizational parameters are present. Recent corpus studies have identified statistically significant properties of musical repertoires in an attempt to explain why we exhibit particular behaviors in response to music. In the present study we asked subjects to identify sequences that are musical versus those that are not. These sequences were then analyzed in order to understand the musical features that guided behavior. In this study, 30 subjects evaluated 50 ten-tone sequences according to musicality (i.e., how musical they thought they were). A special stimulus set was designed that controlled for timbre, pitch content, pitch range, rhythm, note and sequence length, and loudness. Pitch sequences were randomly generated from the white-note collection corresponding to the G-major scale (G3 to F#4). Sequences were then randomly transposed to all 12 pitch-class levels and then normalized so that all sequences resided within the original G3-F#4 span with an equal distribution of pitches across the chromatic scale. Musicality ratings were on a scale of one (not musical) to five (very musical). Subjects were instructed to use their own judgments as to what "musical" meant and were not given guidance. Mean z-scored stimulus ratings from our group of subjects showed significantly distinct groupings of musical versus non-musical sequences. A principal components analysis (PCA) of the ratings yielded three components that explain a statistically significant proportion of variance in the ratings. Using music21, the stimuli were analyzed in terms of parameters such as key correlation, variance, melodic interval variability, and contour. These values were correlated with the eigenvalues of the significant PCA components in order to determine the dominant strategies listeners use to make decisions about musicality. Our work shows that the perception of musicality employs a contextually shifting network of these parameters.

[1A-1.4] Scales and modes: A psychological perspective

*David Huron**

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Music theorists have identified a number of formal properties that distinguish certain pitch-class collections such as scales. Apart from their formal properties, different pitch sets afford different psychological properties, such as melodic anchoring, consonant relationships, and drone opportunities. This paper draws attention to a number of properties that characterize chroma repertoires in different cultures, and also considers patterns of historical change in several of these pitch collections.

Psychological studies related to scale and mode are reviewed beginning with Hevner (1935), through Krumhansl & Kessler (1982), including Crowder's series of studies on the major and minor modes (Crowder, 1984, 1985a/b, Crowder & Reznick, 1991). Large databases have afforded the opportunity to trace diachronic changes in pitch-class distributions, implying a sort of "schematic creep" over several centuries. This includes both slow changes in the major/minor system (e.g., Albrecht & Huron, 2012), as well as interactions in the evolution of medieval Western modes (e.g., Huron & Veltman, 2006).

The observed changes in scale use appear to exhibit properties akin to phonological change in historical linguistics, such as parallels to merger by drift (Harris, 1985), merger by expansion (Herold, 1990), and merger by transfer (Labov, 1994). Interestingly, Hindustani rags have evolved far more rapidly (Jairazbhoy, 1995) than similar changes in Western culture suggesting greater inertia in notational versus improvised cultures. As in linguistics, careful studies of musical change may help to reveal underlying psychological dispositions that shape (or have shaped) the cognition of music.

[1A-2.1] Musical groove modulates motor cortex excitability, and low-frequency effects on rhythmic encoding

*Michael J. Hove (1,2)**
Jan Stupacher (3)
Giacomo Novembre (1)
Simone Schütz-Bosbach (1)
Peter E. Keller (1,4)
Celine Marie (5)
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Groove is often described as a musical quality that can induce movement in a listener. This study examines the effects of groove on corticospinal excitability. Musicians and non-musicians listened to high-groove music, low-groove music, and spectrally matched noise, while receiving single-pulse transcranial magnetic stimulation (TMS) over the primary motor cortex either on-beat or off-beat. We examined changes in the amplitude of the motor-evoked potentials (MEPs), recorded from hand and arm muscles, as an index of activity within the motor system. Musicians and non-musicians rated groove similarly. MEP results showed that high-groove music modulated corticospinal excitability, whereas no difference occurred between low-groove music and noise. More specifically, musicians showed higher MEPs with high-groove music, and this effect was significantly stronger on-the-beat compared to off-the-beat. These results indicate that high-groove music increasingly engages the motor system, and the fine-grained temporal modulation could stem from tight auditory-motor links in musicians. Conversely (and somewhat surprisingly), non-musicians showed lower MEPs for high-groove music, and there was no effect of on- versus off-beat pulses, potentially stemming from suppression of overt movement. Additional analyses of audio features revealed that high groove clips had significantly greater spectral flux in low-frequency bands (i.e., bass energy was associated with groove). In a follow-up study on the effects of frequency on temporal encoding, we used EEG to examine the mismatch response (MMN) to timing perturbations in a rhythmic sequence consisting of low- and high-frequency tones.

[1A-2.2] Stages of beat perception and the influence of metrical incongruity: An fMRI study

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Humans perceive a periodic beat in metric, yet non-isochronous, auditory sequences such as musical rhythms. This beat processing occurs in stages: orienting attention to temporal positions in the rhythm in order to extract the metrical beat (beat finding), anticipating the ongoing beat (beat continuation), and adapting one's sense of the beat to changes in the rhythm (beat switching).

In music, multiple beat-based rhythms are often heard concurrently (e.g., from different instruments), with a single beat rate being induced even when beat rates of individual rhythms are incongruent. This incongruence can manifest in music as polyrhythm or metric ambiguity.

We used fMRI to investigate brain activation across stages of beat perception in both congruent and incongruent rhythmic sequences. Participants listened to auditory rhythms composed of pairs of strongly metric (highly beat-inducing) tone sequences with either congruent or incongruent metrical beat rates. Sequences were presented in either a simultaneous or staggered fashion. For staggered trials, one sequence began, the second faded in, and after playing simultaneously, the first dropped out. This induced a change in the perceived beat, allowing us to investigate beat switching. For each trial, participants either rated the difficulty they had in maintaining a sense of the beat, or listened for a deviant tone.

Results indicated that orienting attention to absolute intervals between events (beat finding) produced greater parietal and cerebellar activations compared to ongoing prediction (beat continuation). Beat continuation produced greater left premotor activations compared to beat finding. Adapting to a changing rhythmic stimulus (beat switching) produced greater anterior insular activations compared to beat finding. During beat perception in the presence of rhythmic incongruence (incongruent compared to congruent trials), we found greater activation in anterior insula, superior temporal gyrus and inferior frontal gyri. These results suggest that distinct neural substrates underlie the stages of beat perception and are influenced by incongruence.

[1A-2.3] Multilevel time-frequency quantification of heart rate variability during passive auditory exposure to tempo changes

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Heart Rate Variability (HRV) is a reliable index of autonomic nervous system dynamics and can be used to disentangle the attentional and affective branches of "neurovisceral integration" in music listening and to explore the role of arousal in the sympathetic-parasympathetic interactions. Electrocardiograms were recorded for 38 participants (13 male, 25 female, aged 18-28 years) passively exposed to different auditory stimulus types: a metronome sequence and techno-style musical loops. Each sequence consisted of five tempo plateaus (levels) lasting 180 seconds at tempi that increased in increments of five beats per minute (bpm), and the sequences were presented at two rates: a slow block from 60 to 80 bpm and a fast block from 120 to 140 bpm. For the metronome condition, we presented sequences of monotimbral ticking sounds with the lowest sonic unpleasantness, the most neutral emotion-inducing capacity, and the maximum likelihood of maintaining attentional focus, as determined in a preliminary study. The techno condition consisted of three percussive rhythmic loops. Given the hierarchical data structures (i.e., tempo levels nested within rate) and large variabilities across participants, Multilevel Modeling was used to predict time-frequency HRV parameters from the fixed effects of tempo level, stimulus type, rate, orders of presentation of type and rate, and significant interactions between them. A random effect for the intercepts modeling the individual differences among subjects was also included. Results demonstrate distinct autonomic responses to several fixed effects in various HRV parameters. When compared to metronome listening, music listening induces parasympathetic withdrawal and increased sympathetic arousal due to its emotional impact, particularly in the higher rate block. Separate trend analyses across types and rates show that increasing the tempo is more likely to prompt cubic or quadratic trends of HRV modulation in the music condition than in the metronome condition, indicating that music listening is governed by an interplay between parasympathetic and sympathetic processes. These findings imply that affective functions (i.e., arousal inducements) dominate attentional functions in the autonomic nervous system's adaptability to auditory rhythmic changes. The present study will potentially contribute to elucidating the mechanism underlying rhythmic music entrainment.

[1A-2.4] Cardio-respiratory synchronization increases emotional arousal during music listening

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Music by its nature has the ability to communicate strong emotions in everyday experiences. Previous research has shown that music listening causes physiological responses, including changes in heart rate, breathing and skin conductance. The present study aims to test the hypothesis that respiratory and heart rate oscillations synchronize as a response to external musical rhythms and the synchronization per se is potentially related to increased emotional arousal. 38 participants with no music training were recruited (18 males, 20 females, aged 18-28 years) to listen to accelerating rhythmic sequences, and three physiological signals were simultaneously recorded: electrocardiogram (ECG), respiration rate (RSP) and skin conductivity (SC). SC was used as a measure of the induced arousal. The musical stimuli used were two 15-minute techno-style music tracks composed from three percussive rhythmic loops. The first track incorporated five steps with ascending tempo (60-65-70-75-80 BPM). The second track was composed from the same three loops but with different tempo steps (120-125-130-135-140 BPM). The steps were of the same 3-minute duration for both tracks. The participant's

cardio-respiratory synchronization was investigated by deriving the music-heart rate, music-respiration and cardio-respiratory synchrograms. In all cases (conditions), long synchronization periods were observed for the wide range of the external musical rhythms used in our experiments. It was found that SC (i.e., arousal) increases during each synchronization period, which supports theories arguing that synchronization of organic systems may be fundamental to emotion. These results not only provide deeper insight into rhythmic entrainment as an underlying mechanism of emotion elicitation, but also have significant implications for affective computing and emotion recognition systems.

[1A-3.1] Implicit measures for dynamic musical affect

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Behavioral measures may be used to study listeners' affective responses to sounds. For example, Sollberger, Reber & Eckstein (2002) primed listeners with chords in a word categorization task. They found that reaction times for congruent conditions (i.e., positive words primed with consonant chords, and negative words with dissonant chords) were faster than for mismatched conditions. In this way, consonant and dissonant chords are implicated with positively and negatively valenced affect, respectively. Unfortunately, such an experimental paradigm may not be effective for longer musical stimuli, such as melodies: priming effects are strongest only when primes are very brief (Rotteveel, de Groot, Geutskens & Phaf, 2001). The aim of this project is to develop a methodology that can implicitly measure affective responses to lengthier passages of music. To this end, participants completed a word categorization task with concurrent musical stimuli. The task is framed as a game, with music playing in the background. Participants categorized words appearing on a screen as either positive or negative, while listening to a) major or minor chord progressions; b) major or minor melodies; or c) nominally happy or sad music. Reaction times were collected continuously. It is anticipated that responses in the word categorization task will be faster and more accurate in congruent conditions (i.e.: positive, major, and happy; or negative, minor, and sad). This would be consistent with the well-corroborated association between the major mode and positive affect, and between the minor mode and negative affect (e.g., Hevner, 1936). Moreover, the method implemented here could be readily adapted for other studies of musical affect.

[1A-3.2] What makes J-pop happy or sad?

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The purpose of this study was to identify lyrical and musical features of Japanese songs that induced happiness or sadness in musically experienced Japanese adults. Through web-based questionnaire and semi-structured interviews, 22 men and 18 women (17-42 years old) attending a vocal training school provided 40 songs that had made them happy and another 40 that had made them sad during their everyday listening experiences. All songs turned out to be "J-pop" (Japanese popular songs). We then analyzed musical features (tempo, minimum, maximum, and range of pitches of the main vocalist) and the content of lyrics (emotion words, emotion-evoking events, and the emotional content of the beginning, the refrain, and the ending of the lyrics). Inter-rater reliabilities of our coding system were very high ($r = .99$ or $ks = 1.0$). Results showed that happy songs ($M = 137.99$, $SD = 27.33$) were faster than sad songs ($M = 91.03$, $SD = 21.72$), $t(78) = 8.51$, $p < .0001$); no other differences were found in musical features whether the main vocalists were male or female. Regarding the lyrics, sad songs contained negative emotion words, $\chi^2(1, N = 40) = 4.71$, $p = .03$, and negative emotion-evoking events, $\chi^2(1, N = 40) = 9.04$, $p = .003$, more than did happy songs, whereas happy songs contained positive emotion-evoking events more than did sad songs, $\chi^2(1, N = 40) = 16.82$, $p < .0001$. One-third of happy songs began positively while one-half of sad songs began negatively, $\chi^2(2, N = 40) = 18.85$, $p < .0001$. Similar tendencies were also found in the refrain, $\chi^2(2, N = 40) = 17.30$, $p < .0001$, and the ending, $\chi^2(2, N = 40) = 13.59$, $p = .001$. These features were surprisingly similar to those identified in children's improvised happy and sad songs reported previously.

[1A-3.3] Timbral influences on perception of structure and affect in Xenakis's Bohor and Metastaseis, investigated by multivariate time series analysis

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In previous work we have shown that acoustic intensity profiles can be strong predictors of continuous-response patterns of perceptions of change and affect expressed by classical and electroacoustic (ea) music. We studied a section of Trevor Wishart's ea piece Red Bird in depth, and initiated study of Xenakis's Bohor. Bohor shares generic patterns of acoustic intensity change across the piece with many other ea pieces we have studied: crescendi are short, with a high rate of change of intensity, while decrescendi are longer and with slower rates of change. Here we used statistical techniques of time series analysis seeking to relate listener perceptions and acoustic properties of part of Bohor, and part of Xenakis's orchestral piece Metastaseis. Multivariate time series analysis is used to model the ongoing process of the perceptual responses. We found that surface timbral features of the latter, such as tremelandi, brass entries, glissandi and silence, though related to acoustic intensity patterns, were separable influences in models of continuous perceptual responses; they constitute perceptually important events. The basic acoustic features of the section of Bohor we studied are more homogeneous, and at least for listeners unfamiliar with the piece, perceptual responses correspondingly are slighter. Possible future developments in the study of perception of Xenakis's electroacoustic music, and ea music in general, are discussed.

[1A-3.4] Predicting emotional ratings of amplitude-normalized and original recordings of Romantic piano trios from their acoustical features

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Emotions in music are conveyed by a variety of acoustic cues (Juslin & Timmers, 2010). For instance, the positive association between sound intensity and arousal is well documented (Juslin, 2000). However, although amplitude normalization is routinely used in music emotion research, direct comparisons between emotional ratings of original and amplitude-normalized musical excerpts are lacking. Moreover, because the relationship between emotional ratings and acoustical cues is to some extent genre-specific (Eerola, 2011), it is advisable to conduct these comparisons over a set of excerpts matched for timbre and compositional style. We therefore examined the relative importance of relevant acoustical cues in the induction of emotions in a large set of Romantic piano trios presented in their original and amplitude-normalized versions.

Thirty participants (non-musicians; 15 females) listened to 84 6-second musical excerpts taken from piano trios from the early and middle 19th century. Participants rated the familiarity, felt arousal, and pleasantness of the excerpts on a seven-point scale. An additional 30 non-musicians (15 females) rated the same excerpts normalized for amplitude. Both low-level acoustical features (such as amplitude and spectral properties) and higher-level features (such as mode) of the excerpts were analyzed using the MIRtoolbox (Lartillot et al., 2008).

Although the shift in arousal between the original and amplitude-normalized excerpts varied in proportion to the amplitude adjustment, arousal and pleasantness ratings were highly correlated between both sets. Linear regression models using five or fewer acoustical features to predict the ratings were determined to be optimal for both sets. All predictors were low-level acoustical features, except for mode. Two parameters, normalized spectral flux and spectral entropy, accounted for more than 60% of the variance in the arousal ratings for both sets, suggesting that although intensity is an important cue for arousal, the latter can be effectively conveyed by other low-level features.

[1A-4.1] Pitch and intonation perception in congenital Amusia: What behavior and reaction times reveal

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Congenital Amusia is a neuro-developmental disorder not caused by insufficient exposure to music, a hearing deficiency, brain damage or intellectual impairment. Amusics show deficits in fine-grained pitch discrimination, i.e., they cannot detect pitch differences of one semitone or less (Peretz et al., 2002; Foxton et al. 2004). It has long been argued that congenital amusia is domain-specific to music and does not affect language (e.g., Peretz et al., 2002). However, growing evidence suggests that this view has to be reconsidered (Patel et al., 2008; Liu et al., 2010) and that congenital amusia influences linguistic pitch perception (intonation).

In the present study, we examined the discrimination of linguistic pitch and two types of tonal analogs (sine tones and pulses) by amusics. We tested eight German amusics (diagnosed with the MBEA: Ayotte et al. 2002) and 32 matched controls in a discrimination task. It was tested whether the amusic group was at a disadvantage when linguistic material was removed. In addition, we looked at the influence of stimulus duration, continuity of the pitch and direction of pitch change (statement or question).

We measured performance accuracy and reaction times. Behavioral results show that amusics performed worse than non-amusics over all conditions. The reaction time analysis supports these findings, as the amusics were significantly slower across all conditions. But both groups were faster in discriminating continuous stimuli than in discriminating discontinuous stimuli and also faster in discriminating questions than statements. Performance accuracy, on the other hand, is inverse, i.e., continuous stimuli and questions were harder to discriminate. In addition, we found that sine stimuli were harder to discriminate (causing longer reaction time) for controls but not for amusics. The present results warrant further investigation of the linguistic factors influencing amusics' intonation perception while considering the relation between performance accuracy and reaction times more closely.

[1A-4.2] Melody discrimination in children with Specific Language Impairment

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Specific Language Impairment is a developmental disorder that occurs in the absence of neurological damage, hearing difficulties or mental retardation (Bortolini, Leonard & Caselli, 1998). A key clinical marker for SLI is very poor non-word repetition (Bishop, North & Donlan, 1996) which has been attributed to a cognitive impairment in the phonological loop component of working memory (Gathercole & Baddeley, 1990). It has been suggested that the phonological loop may be implicated in the maintenance of both verbal and non-verbal auditory information such as music (Williamson, Baddeley & Hitch, 2010), and we hypothesized that an impairment in shared rehearsal mechanisms in the phonological loop component of working memory in SLI would result in poor performance on musical tasks relying on auditory short-term memory. A total of 50 children, 17 with SLI and 33 controls matched for either chronological age and non-verbal IQ or verbal mental age, completed a melody discrimination task alongside measures of verbal short-term memory. It was found that the SLI group showed impaired performance on both the melody discrimination task and the measures of verbal short-term memory relative to children matched for chronological age and non-verbal IQ. The findings support the notion that shared mechanisms implicated in the rehearsal of both verbal and non-verbal auditory information in short-term memory may be impaired in SLI.

[1A-4.3] Musical aptitude and speech-in-noise discrimination in children with Autism Spectrum Disorder (ASD)

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The ability to filter relevant auditory information from background noise is critical for social communication, and impairment of such filtering abilities is a commonly cited feature of autism spectrum disorder (ASD). Musical training has been shown to strengthen speech perception in noisy backgrounds in adults (e.g., Parbery-Clark et al., 2009), and we wondered if enhanced musicianship was related to improved speech perception through noise in children with ASD. Children with ASD (n=23) and typically-developing (TD) controls (n=33), ages 6 through 17, participated in this study. Groups were rigorously characterized via ADI-R and ADOS, and matched on age, gender, and verbal ability. Exclusion criteria included diagnoses of neurological or genetic disorders, and other conditions or illnesses that could affect hearing. Hearing was evaluated via audiometry; all subjects had thresholds <20 dB SPL for 500, 100, 2000, and 4000 Hz, and <25 dB SPL for 8000 Hz. Testing was conducted in a sound attenuated room, and included i) speech-in-noise intelligibility using the Hearing-in-Noise Test (HINT) and ii) musical aptitude testing using either Intermediate or Advanced Measures of Music Audiation tests (IMMA or AMMA; Gordon, 1989). Preliminary results show that children with ASD have impaired HINT abilities ($p<0.005$) and children with ASD have reduced musical aptitudes ($p<0.025$). Moreover, while there was no difference between the number of years studying music between the two groups, children with ASD started musical training 2 yrs prior to TD ($p<0.03$), yet curtailed their training 2 yrs early, resulting in reduced experiences playing in group ensembles ($p<0.02$). It has been shown that children with ASD respond positively to music therapy, yet our findings suggest that music therapy may be curtailed too early limiting group ensemble experiences, improvements in musical aptitudes, and auditory filtering enhancements. (Supported by NIDCD grant DC011094).

[1A-4.4] Music training and simultaneous interpreting: Building new perspectives on blended fundamentals

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The present paper is part of an ongoing interpreting PhD research project. The approach adopted is interdisciplinary, drawing from two fields never before combined (A.Patel, R.Chaffin, private conversation): music and simultaneous interpreting. Interestingly, the link between music and language has intrigued scholars, since it may cast new light on their nature, their evolution, their neural underpinnings, and their dynamics (Besson & Shön, 2001; Bigand et al., 2009; Deutsch, 1991; Deutsch et al., 2004; Huron, 2001; Koelsch et al. 2004; Levitin, 2003; Patel, 2003; Peretz, 2006).

Music and simultaneous interpreting share features and show similarities; musicians and interpreters respond simultaneously to multiple tasks during their performance (Gile, 1998; Gran, 1990). Interpreting music and interpreting languages is a highly demanding cognitive task. In light of previous scientifically-based studies affirming the power of music both on cognition (Moreno, 2009) and developmental functions (Stansell, 2005), the aim of the present study is to investigate differences and similarities between the two profiles, with a special focus on cognition (Gile, 1988).

The aim is to explore whether music training methodologies–related rhythm mechanisms (Grahn, 2009)–improves interpreters' performance. Musicians are usually trained to divide their attention, practicing first-sight playing and memorizing music. Hence, the assumption is to enquire how music training can serve as preparation for the propaedeutic process of interpreting, in an experimental perspective. An experimental study will be carried out on trainee conference interpreters, during their 1st year of training, to observe their interpreting performance, in terms of prosody and fluency. Speeches will be orally-translated during interpreting training sessions considering directionality and effort theory parameters (Gile, 1995). The languages used will be English and Italian (Gile, 2005). The aim is to analyze and evaluate the trainees' performance before and after the music training methodology, showing the first results emerging from the data.

[1B-1.1] Exploring musical emotion using artificial neural networks

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Most of us listen to music because of the emotion it conveys. According to the cognitivist position, although music expresses emotion, the emotion is recognized rather than induced. However, many studies have demonstrated that the recognition of emotion is often accompanied by physiological changes characteristic of real emotion. This latter evidence has been used by the emotivist position as support for the view that emotions experienced during music listening are genuine and not unlike everyday emotions. In this study, we explore this debate further, using computational models of emotion prediction. Specifically, we use artificial neural networks to predict the mean valence/arousal ratings collected from 20 participants on 12 excerpts. As a first step, we designed two networks for emotion prediction. The first network (N1) made predictions using only audio features extracted from music (Vempala & Russo, 2012) while the second network (N2) made predictions using only participant physiological responses. Both networks were trained on eight excerpts and tested on the remaining four. If the cognitivist position is true, N1 should provide strong prediction of musical emotion. If the emotivist position is true, N2 should provide strong prediction of musical emotion. The networks had performance accuracies of 89.9% and 87% respectively, thus rendering both positions as plausible. Yet another position to consider is that appraisals of felt emotion are based on a combination of emotion perceived at a cognitive level and feelings evoked at a physiological level. We explore the plausibility of this hybrid position using two additional models. First, we combine audio and physiological features and compare performance against individual networks. Next, we assume that emotion perception and feeling occur through separate mechanisms weighted together during appraisal. Hence, we combine audio/physiological networks after they have formed hidden representations. We will present results from our computational models and their theoretical implications.

[1B-1.2] Information flow and repetition in music

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The theory of Uniform Information Density (UID) states that there is a tendency for information per unit time to be evenly distributed in a message so that it does not exceed a certain level. While the theory was first proposed for language, it has also been successfully applied to music; it has been shown, for example, that large melodic intervals (which are low in probability, thus high in information) tend to be both followed and preceded by relatively long rhythmic durations. The current paper explores a novel musical application of UID, relating to "altered repetition"–situations in which an intervallic pattern is repeated in a melody but with one or more intervals altered. A generative model of melody will be proposed which considers both the schematic probability of a note (due to things such as interval size and scale-degree) and its contextual probability (reflecting the fact that there is a high probability for melodic patterns to be repeated). If a pattern is repeated with an alteration, UID predicts that the altered interval will be lower in schematic probability (higher in information) in the second instance of the pattern than in the first, counterbalancing the low information in the second instance of the pattern due to it being a repetition. This prediction will be examined in three corpora representing classical themes, European folk songs, and British hymn tunes.

[1B-1.3] On the dimensionality of music similarity

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Almost every year since 2006, the Music Information Retrieval Evaluation Exchange (MIREX) has asked volunteers to rate the quality of the predictions from different models for perceived musical similarity, once on a coarse (3-point) scale and once on a fine (100-point) scale. Although intended only for evaluation, these ratings constitute a very large data set that is rich with as-yet unexplored possibilities for understanding the cognitive factors that underlie judgments of musical similarity.

We are analyzing the similarity ratings from MIREX 2011 using CLASCAL, an algorithm for multidimensional scaling that is known in music perception for its use in understanding timbre (McAdams et al., 1995). Given a set of pairwise similarity ratings (6422 distinct pairs in our case) from multiple subjects (N = 50 in our case), CLASCAL estimates the number J of independent factors underlying the ratings and the number T of distinct rating strategies that subjects employed. It also estimates an appropriate point in a J-dimensional Euclidean space for each element such that the distance between points approximates the subjects' similarity ratings as closely as possible, given the estimated rating strategies. We will examine these points to hypothesize what each of the J dimensions might be and to test whether acoustic correlates to these hypotheses are consistent with the rated audio fragments.

Although music similarity has also been an active domain for researchers in music cognition, including a special issue of Music Perception in 2001, the body of existing studies is too fragmented to provide a unified, high-level theory (Novello et al., 2006). Identifying the dimensionality and possible interpretations of the dimensions of musical similarity, as well as potential rating strategies, our results should help to synthesize previous cognitive literature on music literature and clarify the most promising directions for future studies.

[1B-1.4] Markov pools for music prediction

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A new algorithm for musical modeling is introduced, based on a pool of low order Markov models, where musical context promotes predictions from particular models. Motivated as a solution to issues of combinatorial explosion in Markov modeling, large time windows of events can influence prediction.

To briefly describe the model: A sequence of recent discrete musical events is written:

[context][last N events][?]where[?] is the next event to be predicted. From a pool of Markov Models of order N, a subset are selected (allowing repetitions and perhaps weighted) based on the context; each one is input the last N events to give its own prediction of [?]. The final probability distribution for [?] is the normalized sum of that of all selections. In the training phase, whenever a context event is found in a sliding window, the associated model is trained via the most recent (N+1)-gram.

The algorithm was tested over the full Essen folk song corpus, predicting the next note in monophonic melody given previous notes. A pool of second order Markov models was trained over 50% of the corpus, and tested on 50%. Direct prediction scores were higher than either second or third order Markov models alone, prediction by partial match, and basic rule-based strategies. Basic Markov models exhibited slightly lower cross-entropy (Pearce & Wiggins, 2004); however, the Markov Pool is much denser in the spread of its probability mass than the relatively sparse single Markov model (especially as model order increases).

Since the nature of the context can be extended to more complex musical events like held pedal notes and other polyphonic material, and the model generally applied to further viewpoints such as rhythmic information or joint pitch and rhythm (Conklin & Witten, 1995), the model is a promising resource for investigation.

[1B-2.1] The role of factors associated with emotion in experience of elapsed duration during music listening

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The effect of emotion and associated states on experience of duration during music listening is little-understood. Processing of musical information in the range of the supra-second has historically been discussed in terms of memory and attention. The acknowledgement of the role of emotional response during experience of duration (in the range of multiple seconds) is a recent addition to models of psychological time. A previous study (Phillips & Cross, 2011) suggested a positive correlation between ratings of enjoyment and estimate of duration during music listening. The current study further explores this link, by investigating the possible correlation between ratings or arousal, valence, familiarity and 'finishedness' (the extent to which the music felt complete, or closed) on estimates of time elapsed during music listening. Participants heard a 37-second extract of bespoke tonal music for solo piano (100bpm), and retrospectively estimated time elapsed during the period ('Without looking at your watch or a clock, how long do you think you were listening to the music? Minutes: X, seconds: X'). All questions were answered in written format. Study 1 (N=23) did not reveal any correlation between duration estimate and ratings of arousal or valence. Study 2 (N=66) suggested a positive correlation between ratings of 'finishedness' and estimate of elapsed duration ($p<0.04$), between ratings of enjoyment and familiarity ($p<0.01$) and between arousal and familiarity ($p<0.03$). These studies suggest that retrospective verbal estimation of elapsed duration during a 37-second music listening period may be influenced by sense of enjoyment (Phillips & Cross, 2011) and 'finishedness.' Furthermore, enjoyment may influence, or be influenced by, sense of familiarity. Results may be interpreted in terms of information processing theories and existing models of psychological time. Moreover, results suggest that important relationships may exist between sense of arousal, familiarity and enjoyment during music listening.

[1B-2.2] Emotional communication of classical and popular pianists through pieces from Brazilian's repertoire

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The term "emotional communication" refers to those situations in which performers have the intention of communicating specific emotions to the listeners. Therefore, musical communication accuracy occurs when the emotion intended by the performer is understood by the listener. The goal of this work was to determine the musical communication accuracy between pianists and listeners in Brazilian music context. Two experiments were carried out. In the first, 5 classical and 5 popular pianists recorded musical sections from Brazilian repertoire, which they believed to communicate Happiness, Sadness, Anger and Serenity to their listeners. Experiment was run in a silent room, acoustically isolated. Excerpts were recorded through a Grand Piano Steinway B, amplified through a microphone Behringer B2 Pro, connected to a MacBook White. Excerpts were registered and edited through Logic Pro 9. Data showed that similar acoustic cues referring to mode, tempo, articulation and sound level were employed to communicate Anger for both groups. Furthermore, differences were found in terms of acoustic cues to communicate Happiness, Sadness and Serenity for both groups: classical pianists employed similar cues to the ones suggested by Expanded Lens Model whereas popular pianists employed acoustic cues which is not contemplated by the model. In the second experiment, 17 musicians performed a task of listening to the musical excerpts recorded from the previous experiment. Experiment was run in a silent room, with a computer LeNovo connected to a headphone Koss R80. This experiment was run through E-prime 2. After listening each excerpt, they filled in semantic scales (range 1-9) referring to the four intended emotions analysed in this study. Results suggested that, in general, popular pianists communicated Happiness, Sadness and Serenity more accurately than classical pianists. However, the same level of accuracy was found between popular and classical pianists to communicate Anger to their listeners.

[1B-2.3] The influence of story ending and music on perceived protagonist emotion, viewer emotion, and enjoyment

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Affective Disposition Theory (ADT) states that viewers of film (or other storytelling media) typically form a positive disposition (a liking) toward the protagonist, and subsequently enjoy the story more when the protagonist has positive experiences and enjoy it less when the protagonist suffers. Although music psychology shows that music can influence the perception of film characters, the role of music in relation to ADT has not been explored.

This study examined the influence of narrative and music on three variables central to ADT: perceived protagonist emotion, viewer emotion, and enjoyment. Participants (N=194) were randomly assigned to watch one of six versions of a video containing positive, negative, or no music at the beginning of the story and an ending that rewarded or punished the protagonist. Results supporting ADT indicated that perceived protagonist emotion and viewer emotion were relatively positive in the reward conditions and relatively negative in the punishment conditions. Furthermore, protagonist emotion was correlated with viewer emotion in all six conditions. Contrary to ADT predictions, the ending did not influence enjoyment measures, nor was enjoyment correlated with viewer emotion. Enjoyment was marginally correlated with protagonist emotion in the positive music/punishment condition only. The presence of any music (positive or negative) at the beginning of the narrative augmented the effect of the ending on perceived protagonist emotion. That is, music created the perception that protagonist emotion in the reward ending was even more positive, and protagonist emotion in the punishment ending was even more negative. Negative music augmented the effect of the ending on viewer emotion, but positive music had no effect.

The results indicate that music may have direct effects, but the effects of music may also vary as a function of music-story interaction. Possible explanations for these effects are explored.

[1B-2.4] Imitation training to enhance emotion perception skills

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It has been found that individuals automatically generate simulations of other people's facial expressions during speech and song to aid in emotion perception. This has been called the facial feedback hypothesis. It has been suggested that this simulation mechanism is related to mirror neuron system (MNS) activity; individuals with greater empathy generate greater MNS activity and greater automatic mimicry of other people's movements, while the opposite is true for people with disorders involving empathy. In the current line of studies, I propose that we can exercise the MNS using purposeful motor mimicry via imitation training. Imitation training involves explicitly asking participants to imitate another person's facial movements. The use of song stimuli followed by speech stimuli is predicted to facilitate this process. I will discuss possible implications for patient groups ranging from autism to Parkinson's disease. Current preliminary data suggests that individuals with low scores on an empathy scale generate greater emotional intensity ratings after imitation training towards vocally-expressed emotions.

[1B-3.1] Singing in tune: Insights from music educators and psychological researchers

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The term "tone-deaf" is used colloquially to describe out-of-tune singers. While this term suggests that these individuals have faulty pitch perception, it is typically used to mean that they have faulty pitch production. Amusia, on the other hand, is a term proposed to refer to a developmental disorder that is characterized primarily by a deficit in pitch perception. An interdisciplinary study was conducted to explore these two conditions and possible reasons for out of tune singing.

The first component consisted of interviewing 4 singing teachers and asking them for their experiences with out-of-tune students. An analysis of the interviews revealed common themes, including observations that out-of-tune singers seem to have difficulty hearing differences between pitches, trial-and-error methods of teaching based on individual students' progression or lack thereof, and a strong belief that everyone can eventually be taught to sing in tune with enough effort and the right methods.

The second component reviewed the literature on "tone deafness" and amusia and made a case for visuospatial (VS) deficits as one possible cause of out-of-tune singing. A research experiment was conducted to examine this hypothesis. A variety of VS tasks were given to 58 participants who fell into 4 categories: amusics, "out of tune" singers who did not have amusia, experienced singers, and non-musicians. Results showed that while those with amusia did not have general deficits in VS ability, they do appear to have a significant deficit in VS working memory. The out-of-tune (but non-amusic) singers did not have this VS deficit, highlighting the separability of the two conditions.

The third component examined ideas for bridging the gap between music researchers and music educators and how each discipline can best inform the other in order to achieve the mutual goal of aiding those with music learning challenges.

[1B-3.2] Singing accuracy in the general population: A comparison of kindergarten and adult data sets

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Singing and perceptual skills develop as young children age and gain greater musical experience. Data from earlier longitudinal studies suggest that singing accuracy improves steadily from grade one through grade six with a marked improvement at grade six, but few if any studies have attempted to track singing accuracy through the life span. Recent research in music cognition has focused on adult singing accuracy and perceptual skill, but we have little data on how these subjects compare with the many studies on children's singing accuracy. There is limited data on the population from grade six to adult, and recent studies of adults often do not use methods consistent with earlier child studies. The purpose of this study was to compare directly the singing accuracy results of two data sets, one adult and one child (age 5-6), that were gathered using a similar methodology. The research questions were: 1) What is the prevalence of singing accuracy in the two populations? 2) How do measures of accuracy and precision compare with measures such as absolute note error in characterizing accurate singing? 3) Do the results change if human versus machine scoring is used?

Based on a lifespan developmental view, we might expect the results of the adult data set to be superior to that of the kindergarten group, but that was not the case. While there were some differences in distribution, the adults and kindergarteners were similar in their mean scores, and the kindergartners actually had more singers that scored in the 90th percentile. These results and those comparing scoring methods and definitions will be discussed in terms of creating a more unified approach to assessing singing accuracy and beginning to construct a picture of skill development across the life span as it relates to age versus experience.

[1B-3.3] Towards a new tool for describing singing ability: Evaluating Icelandic 5-year-olds' performance on the AIRS test battery

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The assessment of singing ability in children has been the object of several studies in music education in the past. Two rating scales have most often been used to evaluate singing proficiency in school age children. These scales have either been used separately or combined as they do not focus on the same aspects of singing. Both rating scales depend heavily on culture based evaluations by judges and predetermined notions of "appropriate" singing and "proper" use of singing register. A more neutral tool is needed to analyze children's singing and the data collected through the AIRS test battery of singing ability.

Rather than evaluating the singing quality with reference to use of singing range, this study applies a new analytic tool for children's singing based on elements found in the literature on melodic perception development. The tool evaluates the pitch matching, melodic contour and form preservation in singing.

The tool was applied to analyze the singing of Icelandic 5-year-old children in three test items from the AIRS battery. These items included: 1) a call-response singing game, 2) singing of major scale intervals, 3) singing of a well known children's song. A significant correlation was found between items 1 and 2. Item 3 had a high but non-significant correlation to the other two items. Further tests on singing data from other countries and other age groups are needed to test the usefulness and validity of the new tool.

[1B-3.4] The effects of distributed and massed singing training on performance and mood in novice singers

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Singing is a popular and culturally universal endeavour. Despite this, the influence of training and training parameters on singing ability are not well understood. Furthermore, group singing has been shown to have a positive influence on mood, yet the possible psychological benefits of solo singing have received limited consideration. This study used a longitudinal, randomised design to examine the effects of six weeks of solo singing training on pitch discrimination ability, pitch production accuracy, and mood. Participants were randomly assigned to a massed or distributed practice condition and underwent singing training using digital media. Participants in the massed condition practiced continuously for 100 minutes once per week, while those in the distributed condition practiced for 20 minutes five times per week. Preliminary analyses in a subset of participants that have completed the training (n=19) suggest that distributed singing practice led to greater improvements than massed singing practice in pitch discrimination ability, with a significant group x time interaction, $F(2, 34) = 3.53$, $p = .04$. Although most participants were accurate singers at baseline, in a small group of poor singers (n=5), significant improvements in pitch production accuracy were observed after training. Mood evaluations before and after singing testing sessions showed within-session increases in positive mood and decreases in negative mood, regardless of practice condition. Ongoing analyses will provide a more detailed account of the effects of the spacing of practice on the acquisition of singing skills and on mood.

[1B-4.1] Bridging the gap between sound and meaning

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The ability to associate sounds and derive meaning from them is a skill used on a daily basis. This assists with identifying faces associated with voices heard over the phone, making inferences about unseen objects, and even obtaining status updates in complex environments such as airplane cockpits or hospital emergency rooms. Interest in this third type of association has grown recently due in part to interest in standardizing alarms in hospitals. Unfortunately these efforts have not proven fruitful—these alarms are poorly learned, not easily recalled, and are highly susceptible to confusion (Sanderson, Wee, & Lacherez, 2006; Wee & Sanderson, 2008). One survey revealed two critical alarms were missed per day in a single hospital Intensive Care Unit (Donchin et al., 2003). With Ontario's 160 hospitals servicing a population of 13.5 million, this corresponds to 116, 800 alarm-related errors annually. These problems could be attributed, in part, to the abstract nature of alarm concepts and the difficulties they impose on associative memory.

Here, we explore differences in our ability to associative concrete objects and abstract concepts with short melodies; assessing performance according to both recognition and recall. Our results indicate better recall for concrete rather than abstract associations. Outside of the realm of auditory alarms, musical motifs have been quite successful in making cognitive links in advertising (jingles) and telecommunications (ringtones). Additionally, they play an important role in a variety of musical settings such as opera and musical theatre, where audiences must retain associations between music and characters/moods/etc. This taken together with the experimental results can inform us of the cognitive limitations of associating melodic sequences and may help inform training routines in applied settings such as the design of auditory alarms.

[1B-4.2] Speed of detection and perceived duration of deviant auditory oddballs: Test of a novel pitch-window hypothesis

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Durations of deviant (oddball) stimuli embedded within a series of otherwise identical (standard) stimuli tend to be overestimated. Two experiments explored the nature of the auditory oddball effect using a tone-sequence paradigm. Our goal was to test a novel pitch-window hypothesis, which predicts that when most events (tones) occur within a fixed pitch window (range), rare events that occur outside this window will be detected faster and perceived to be longer than rare events that occur within this window, regardless of the absolute pitch distance of those rare events from the pitch of a standard (referent) tone. On each trial, participants heard an isochronous nine-tone sequence consisting of eight 350-ms 400-Hz standard tones and one embedded oddball tone, which differed in pitch from the standards, in the 5th - 8th sequence position. Participants either responded as quickly as possible upon hearing a fixed-duration oddball (Experiment 1) or judged whether a variable-duration oddball was 'shorter' or 'longer' in duration than the standard (Experiment 2). Participants were randomly assigned to either a narrow pitch-window context, wherein a near-pitch (550-Hz) oddball was presented on 75% of trials, or to a wide pitch-window context, wherein a far-pitch (850-Hz) oddball was presented on 75% of trials. In both contexts, an intermediate-pitch (700-Hz) oddball was presented on the remaining 25% of trials–thus occurring either within (wide context) or outside (narrow context) the pitch window. Consistent with the proposed pitch-window hypothesis, results indicate that the same (700-hz) oddball was detected more quickly and perceived to be longer when presented in the narrow context (outside the window) than when it was presented in the wide context (within the window).

[1B-4.3] Cognitive benefits of music and art training in healthy older adults

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It is well documented that music training offers a variety of cognitive benefits. Emerging evidence suggests that musical activity late into life may preserve cognitive functioning in old age. Considering the rapidly growing aging population, it is crucial to study the effects of music or other types of training as a way to mitigate age-related decline in cognitive functions. Here we explore whether short-term engagement with different forms of training (music and visual arts) can provide the aging brain with cognitive benefits. Specifically we assess whether or not training can improve attention and inhibitory control which often declines with age.

Based on age, education and IQ, older adults (age range: 57-82 years) were pseudo-randomly assigned to either a music training group (n=18) or a visual art training group (n=19). Each group received either music or visual art lessons with a professional teacher in a class for three months (36 one-hour sessions, three times per week). Before and immediately after training, cognitive skills were assessed behaviorally with a neuropsychological test battery, and with an auditory task using the mismatch negativity (MMN) paradigm and a visual Go/NoGo task during electroencephalographic (EEG) recording.

Following training, both groups demonstrated improvement in WASI similarities, Digit Symbol, Stroop and Cattell which could be associated with test repetition. Interestingly, however, evoked brain responses showed domain-specific effects in each group. In the auditory MMN, the music group showed enhanced MMN amplitude in fronto-central sites. In the visual Go/NoGo task, the visual art group showed enhanced P3 amplitude at fronto-central sites suggesting a domain-specific brain plasticity effect of training. Additionally, both groups showed faster N2 latency (front-central and central channels).

Results suggest the possibility that music and art training can be an effective intervention for sustaining or improving skills in cognitive aging.

[1B-4.4] Interactions between early music-related training and musical environment at home on children's cognitive-adaptive skills

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Even though cognitive benefits of music training have been replicated over the years, it is still unclear whether early exposure to music at home plays any role in this equation. We are investigating this issue with Japanese children 5-7 years of age. The following information is based on the currently available data of 18 children. Nine children began taking formal music-related training (music, ballet) when they were 11 months to 5 years and 10 months old (M = 3.42, SD = 1.75), and their accumulated duration of music education ranged from 8 months to 4 years and 7 months (M = 2.50, SD = 1.42). The others had never taken such training outside of (pre-)school education. Information about these children's musical environment at home—at 6-month-olds and the current—and basic demographics were obtained from their mothers through a questionnaire. These children's cognitive abilities were measured by Kyoto Scale of Psychological Development 2001, a standardized measure widely used in Japan. In particular, we selected 16 tasks of the cognitive-adaptive ability subscale. Of those 9 tasks were expected to be completed by 50% of 3-year-olds to 6-year-and-5-month-olds ("lower-age tasks"), and 7 tasks by 50% of 6-year-and-6-month-olds to 10-year-olds ("higher-age tasks"). Permutation t-tests showed that positive effects of training were evident among children of musically rich homes, $t_{obt}(5) = 2.73$, $p = .04$, $d = 2.85$ (total score), $t_{obt}(5) = 3.15$, $p = .02$, $d = 2.89$ (higher-age-task score), $t_{obt}(5) = 5.94$, $p = .009$, $d = 4.58$ (higher-age spatial-temporal task score), $t_{obt}(5) = 3.71$, $p = .01$, $d = 3.51$ (higher-age spatial-temporal task efficiency), but not among those of musically poor homes. The issues of family income and parental academic achievement will be discussed in the conference.

[1C-1.1] Effects of harmonic context on pitch perception

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Whereas numerous studies have illuminated cognitive aspects of pitch and harmony (e.g., Krumhansl, 1990, Deutsch 1999, Cross 2007, Cook 2009, Yeary 2011), the experimental research examining the perceptual processes involved in the interaction of pitch and harmony is notably scarce. Aimed to contribute to our understanding of these processes and motivated by the important role that harmony plays in the definition of tonality, this paper presents an empirical investigation of the effects of harmonic context on pitch perception.

Participants performed a same/different discrimination task on two tones–a reference tone (RT) and a comparison tone (CT)–that were embedded within a single melody with clearly implied harmonies. To minimize potential confounding effects such as intervallic context and number of different notes between RT and CT, 120 musical examples were composed by the experimenter. Visual cues facilitated the identification of the two tones. The experimental design consisted of three factors: pitch (same/different); harmony (same/different harmonic context for CT and RT); and harmonic stability (equal/unequal; i.e., either CT and RT were consonant members of their respective harmonies, or one tone was consonant and the other dissonant).

The results revealed significantly better discrimination of same than different tones, better pitch discrimination for nonchanging than for changing harmonic contexts, and better pitch sensitivity in unequal compared to equal harmonic-stability conditions. In addition, the discrimination of same pitches was better for equal than for unequal harmonic stability, whereas the reverse was true for different pitches. Further, in the unequal harmonic-stability condition (i.e., when one tone was consonant and the other dissonant), pitch discrimination was equally accurate for same and different tones. Altogether, these findings suggest that tones belonging to different and adjacent harmonic functions tend to be perceived as the same in pitch, particularly when they are consonant members of their contextual harmony

1C-1.2] The effects of intonation accuracy on perceived vocal performance quality

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The belief that intonation accuracy is a key determinant of musical performance quality is ubiquitous in music pedagogy; nonetheless, empirical validation of this belief is lacking. In the current study, recordings of six vocalists performing three songs each were digitally manipulated to create three versions of each performance: one in-tune, one moderately out-of-tune (half of the tones 25 cents flat), and one severely out-of-tune (half of the tones 50 cents flat). Two vocalists used vibrato and also recorded versions of each song without vibrato. In Experiment 1, 18 participants rated the quality of each performance across the three tuning conditions (a total of 24 stimuli including vibrato and suppressed-vibrato performances by two of the vocalists). Participants then rated the intonation accuracy of these 24 stimuli. As expected, ratings of performance quality and intonation accuracy suffered in both out-of-tune conditions, although moderately out-of-tune performances were rated only marginally lower than in-tune performances. However, performances with vibrato were less affected by intonation inaccuracies than other performances, suggesting that vibrato may mask tuning inaccuracies. To assess whether perceived performance quality varies according to one's ability to detect mistunings, Experiment 2 compared participants with high and low scores on a mistuning detection task. Twenty-four intonation-sensitive and twenty intonation-insensitive participants rated the same stimuli used in Experiment 1. Intonation inaccuracies were more detrimental to performance quality ratings made by intonation-sensitive participants than those made by intonation-insensitive participants. Furthermore, intonation-sensitive participants were far more accurate in their judgments of intonation accuracy. Although intonation inaccuracies appear to be detrimental to performance quality in general, the use of vibrato and the intonation sensitivity of the listener may mediate this effect.

[1C-1.3] Effect of timbre on voice recognition in two-voice counterpoint music

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Timbre saliency refers to the attention-capturing quality of timbre (Chon & McAdams, 2012). It turned out to be related to the spectral distribution of harmonic energy, based on an experiment with 15 instrument timbres. It also showed a negative correlation with the perceived degree of blending with other timbres, verifying that a salient sound tends not to blend well with its neighbors [Chon & McAdams, 2012).

To explore the effect of timbre saliency and timbre dissimilarity in a more realistic setting, voice recognition in two-voice counterpoint music was studied. Excerpts were selected from J. S. Bach's Trio sonatas for Organ, BWV 525 – 530. They were realized with six sets of timbres chosen according to timbre saliency (both high, both low, or opposite saliency) and timbre dissimilarity (close or far) conditions. The excerpt was followed by an isolated voice, which was either identical or had the pitches of two notes changed. Listeners without absolute pitch were asked to judge whether the isolated melody was the same or different as the one in the two-voice excerpt.

Average percent correct ranged from 58.9% to 92.9% per participant, with a global average score of 75.6%. There were no significant differences observed from these per-participant averages according to the age, gender, or self-identification as either professional or amateur musicians. The only significant factor was the voice type (high or low), and neither timbre saliency nor timbre dissimilarity condition was significant in a three-way ANOVA. In two-way ANOVAs per voice, there was no effect of timbre saliency or dissimilarity for the high voice, but for the low voice there was a significant effect of timbre dissimilarity (easier to recognize with dissimilar timbres on the two voices), but not of timbre saliency. This result suggests that having highly dissimilar timbres on the voices helps recognition of the low voice, probably due to stream segregation by timbre difference.

[1C-2.1] Stability of melodic patterns in oral transmission

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We define melodic stability as the resistance to change of melodic patterns in oral transmission. Oral transmission, in which songs are passed on without the help of notation, relies on human abilities of perceiving and recalling of auditory pattern.

We aim to model how melodies belonging to a 'tune family' (a collection of folksongs that are considered variations of the same tune; (Bayard, 1950) evolve over time and space, by comparing elements remaining relatively unchanged (stable melodic patterns or 'motifs') to those that vary considerably. The Dutch Song Database (http://www.liederenbank.nl) provides a rich source to study oral transmission, in order to reveal potential cognitive mechanisms that might constrain this transmission, including processes of perception, memorization, and recall (Honing, 2010: 122). The recall of epic poems and song lyrics has been shown to be facilitated by the presence of constraints, such as rhyme, meter and semantic function, which establish conditions for a word to appear in a certain place (Rubin, 1995). The simultaneous presence of several constraints limits the search space for the 'correct' word.

For melodies, we assume a similar process. The presence of rhythmic and melodic constraints limits the range of possible continuations of a melody. Accumulation of such constraints would cause a melodic pattern's relative stability.

Combining insights from an interdisciplinary literature research, we arrive at a number of hypotheses for musical structures providing constraints in oral transmission of folk songs, such as melodic anchoring (Bharucha, 1996), metric and harmonic relationships. Listening expectations resulting from exposure to the repertoire (cf. Huron, 2007) might be considered as the overarching principle in the development of such constraints.

In order to identify stable patterns on which these hypotheses can be tested, we propose a pattern matching approach using suffix trees.

[1C-2.2] The evaluation of singing voice accuracy: Are we good judges even if we are not musicians?

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A previous study highlighted that objective and subjective measurements of vocal accuracy are highly correlated when the rating is done by musicians and that 81% of their variance was explained by the pitch interval deviation and the number of tonality modulations (Larrouy-Maestri, Lévêque, Schön, Giovanni, & Morsomme, 2013). However, the general audience is not expert in music. This study aims to observe the vocal accuracy assessment done by non-musicians.

Eighteen non-musicians were asked to rate on a 9-point scale the global pitch accuracy of 166 vocal performances sung by untrained singers. This database was presented two times (T1 and T2) in a random order. The sung performances were objectively analyzed regarding three criteria: pitch interval deviation, number of tonality modulations and number of contour errors.

The results show an intraclass correlation coefficient of .89 ($p < .01$) among the non-experts and a mean intra-judges Spearman correlation of .66 (SD = .06) between T1 and T2. There is also a significant correlation between the acoustic measurements and the mean ratings ($r(166) = .809$; $p < .01$), with higher scores for accurate performances. Confronted with the music experts of the previous study, the judgment of the non-experts correlated with the musicians ratings ($r(166) = .840$; $p < .01$). However, a Mann Whitney test showed that the rating of non-experts was globally more severe than the experts one ($p = 009$). In addition, the regression analysis showed that only the pitch interval deviation criterion was considered in their judgment, explaining 66% of the variance of the judges.

This study highlights the reliability and the objectivity of non-musicians in the vocal accuracy assessment. Moreover, an effect of music expertise is observed concerning the severity of the rating and the vocal accuracy assessment process.

[1C-2.3] Of tonality, tuning, and tweets: Micro-tuning aspects of singing across species and across humans differing in singing skill

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Investigations of singing accuracy typically focus on errors in pitch production (i.e., singing the "wrong" pitch) while leaving unexplored the extent to which singers tune intervals to ideal categories, as specified by a tuning system (typically equal temperament). Such microtuning effects were recently highlighted in an analysis of singing by nightingale wrens (Araya-Salas, 2012). This species has typically been considered to be among the most "musical" of songbirds. However, an analysis of microtuning by Araya-Salas suggested that birds do not tend to tune sung intervals to musical chromas, in sharp contrast to his analysis of instrumental music performed on flexibly tuned instruments (e.g., the violin). These results were taken to suggest that songbirds are not producing "music" as per the standards of Western tonality (which had been claimed previously). We applied the analysis method of Araya-Salas to human vocal music in order to address whether human singer–who are intending to produce music, which is not clear for birds–microtune to ideal musical intervals. Surprisingly, humans exhibited no greater tendency to tune intervals musically than did birds. This was true for singers across a wide range of skill levels, including singers considered to be aesthetically pleasing to listen to. These results introduce provocative questions concerning the role of tuning systems in musical perception and production, musical aesthetics, and the use of performance data to explore musical intentions.

[1C-3.1] The tonal and metric hierarchies are correlated, but variable

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It is commonly assumed that metrically stable positions preferentially feature tonally stable pitches, and that tonally stable pitches occur more often than not at metrically stable locations. Like many assumptions, however, there is actually little explicit evidence supporting this hypothesis. To investigate the validity of this assumption, we analysed a corpus of compositions by Bach, Mozart, Beethoven, and Chopin, measuring the frequency of occurrence of each of the 12 pitch classes at all possible temporal positions in the bar.

There were two primary measures in this analysis. First, the average tonal stability of each metric position was calculated and correlated with metric hierarchy values. This measure (tonal-metric hierarchy) tests whether tonally stable pitches have high metric stability and if tonally unstable pitches have low metric stability. Second, the average metric stability of each pitch class was calculated and correlated with tonal hierarchy values. This measure (metric-tonal hierarchy) indicates whether metrically stable positions feature high tonal stability and metrically unstable positions have low tonal stability.

Aggregating across composers, both measures showed strong positive correlations ($r = .62$ and .52, respectively). More interestingly, the correlations varied between composers. Bach de-emphasised the tonal-metric hierarchy while following the metric-tonal hierarchy ($r = .29$ and .77). Mozart followed the opposite pattern ($r = .63$ and .46), but not as extensively as Chopin ($r = .79$ and .43). For Beethoven, both measures were comparably high ($r = .61$ and .66).

Examination of the frequency of co-occurrence of tonal and metric information showed that, overall, the tonal hierarchy was more exaggerated at metrically stable positions and less differentiated at lower levels of metric stability. The existence, profile, and constancy of the tonal-metric hierarchy is relevant to several areas of music cognition research, including pitch-time integration, statistical learning, and global effects of tonality.

[1C-3.2] Building a representative corpus of classical music

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A model for the construction of a corpus of classical music from the "common practice period" (1700-1900) is developed using specific composers, historical styles, and musical genres (e.g., symphony, chamber music, songs, operas) as its sampling parameters. The corpus aims to capture the range musical idioms that comprise the contemporary musical environment, and hence represent what contemporary listener is most likely to have heard.

Five sources were used in the construction of the model: (a) The Oxford History of Western Music by Richard Taruskin (2005), (b) amalgamated Orchestral Repertoire Reports for the years 2000-2007, from the League of American Orchestras, (c) A list of titles from the Naxos.com "Music in the Movies" web-based library, (d) Barlow & Morgenstern's Dictionary of Musical Themes (1948), and (e) for the composers listed in sources (a)-(d), counts of the number of recordings each has available from Amazon.com. General considerations for these source types are discussed, and specific aspects of each source are then detailed. Strong inter-source correlations were found for sources (b), (c), and (c) (Spearman's rho ranged from $r_s = .488$ to $r_s = .596$, $p < .001$ in all cases) sources, save for the Taruskin History (no significant correlations).

Using the Amazon.com data to determine weighting factors for each parameter, a preliminary sampling model is proposed. Including adequate genre representation leads to a corpus of ~300 pieces, suggestive of the minimum size for an adequately representative corpus of classical music. The approaches detailed here may be applied to more specialized contexts, such as the music of a particular geographic region, historical era, or genre.

[1C-3.3] Name that tonic: A new key-finding algorithm using Euclidean distance

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For many years, automatic key finding has posed unique problems for computational music theorists and those interested in working with large corpora. In order to conduct studies involving scale- degree information or tonal functions on large collections of works, one must ensure that keys are assigned as accurately as possible. It is difficult, however, to create an algorithm that simultaneously allows for the flexibility of tonicizations and the inclusion of chromatic pitches, while nevertheless determining an overarching key. The current report proposes a new key finding algorithm, utilizing Euclidean distance rather than correlation, and examining only the first and last eight measures of each piece. A model was trained on a data set of 490 pieces encoded into the Humdrum "kern" format, and was tested on a reserve data set of 492 pieces. The proposed model was found to have a significantly higher overall accuracy (93.1%) than many previous models, such as the (88.6%) Temperely Kosta-Payne (2007), the (74.2%) Krumhansl-Schmuckler (1990), the (91.1%) Bellman-Budge (2005), and the (91.7%) Aarden-Essen models (2003). In addition, separate accuracy ratings for major mode and minor mode works were determined for each of the existing key-finding models in which it was found that most other models provide significantly greater accuracy for major mode rather than minor mode works. The proposed key-finding algorithm performed more accurately on minor-mode works than all of the other algorithms tested, although it did not perform significantly better than the models created by Aarden or Bellman. The proposed model and the Aarden-Essen model were found to have complementary results. Consequently, a post-hoc algorithm that combines the two models is suggested, and results in significantly more accurate key assessments (95.1%) than all the other extant models.

[1C-4.1] Tracking tracks through time: Exploring the changing fortunes of artists and songs via music downloading

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In the summer of 2012 the author entered into a 5-year data sharing and cooperation agreement with the Nokia Corporation, with the objective of establishing a digital music lab at McMaster University dedicated to the analysis of the Nokia's vast music-download database from sociocultural and musicological perspectives. Nokia currently has online music stores in some 40 countries, representing all areas of the globe; in total, over 20 million tracks are available in all genres. The data provided by Nokia cover a five-year period from 2007 to the present, which allows music-listening patterns to be studied longitudinally and at a global level. The dataset contains hundreds of millions of metadata downloads, with information pertaining to country, (anonymised) user, date, time, artist, genre, subgenre, and so on.

The research presented in this paper explores the ways in which the fame of artists, bands and their songs spreads across the globe. Two hypotheses are tested. The first proposes that the instantaneous nature of modern mass communication leads to the random spreading of fame, in which popularity arises in multiple countries more-or-less simultaneously. The second hypothesis suggests that the popularity of artists and/or songs follows certain pathways, either through the global coordination of track-release dates or, more interestingly, because some countries are consistently "ahead of the curve" with respect to spotting rising talent and musical innovation. The influence of song-type and genre will also be considered. Finally, the research will study trajectories of fame longitudinally through time, and seek to understand the dynamics of the birth, life and (artistic) death of musicians and their music.

Download information are organised using a relational database management system and queried using the MySQL implementation of SQL (Structured Query Language). In addition, data mining algorithms will be used to sort, filter and perform various analyses used within the research.

[1C-4.2] Approaching perfect Ezan: How technology is changing the 1400 year old tradition of the Islamic call to prayer

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This article examines two different approaches in recent attempts to standardize ezan (Islamic call to prayer) in Cairo and Istanbul respectively. Drawing on fieldwork in Istanbul and western Anatolia, interviews with Muslims living in Canada, and abroad, existing academic literature, and news articles and editorials on the subject, comparisons will be presented with regard to the rationale for and process of standardization in each city. The argument will be made that although the Egyptian and Turkish sociopolitical relationships with ezan have historically been markedly different, and the recent approaches taken by each country to achieve standardization may appear to run counter to their respective predilections with regard to Islam and modernity, their intent and motivation are analogous. The evolving and often contentious relationship between technology and ezan will be addressed in order to contextualize recent modernizations within a broader historical timeline. Special attention will be paid to the Turkish ezan, with examples provided based on my own fieldwork in Turkey, and particularly Istanbul, with the intention of further contextualizing the pervasiveness and relevance of this ancient tradition within a city that seemingly grapples with the push and pull of modernity and antiquity. This article is part of a larger and ongoing research document that focuses on the cultural connotations of ezan within the modern Turkish milieu. Of particular interest to the SMPC conference is the fact that ezan, although it is; melodic, built on a strict musical framework known as makam modal system, performed in many cases by trained singers, and an elaborate solo vocal improvisation, *it is not considered music*.

[1C-4.3] Tonal features of Zulu song prosody: A phonetic study

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The relations between song and speech have long been recognized to occupy a special place in the study of African music. The work of musicologists and linguists such as A. M. Jones, J. H. Kwabena Nketia, John Blacking, Gerhard Kubik, and Kofi Agawu—among many others—have detailed the inextricable links between these two communicative systems. One important reason for this persistent interest is the predominance of tone languages in sub-Saharan Africa. Speech tone has been widely recognized as an important, if not determining, factor in song melodies. But the relative importance of tone in many African languages has remained largely conjectural due to imprecise methods of transcription and analysis. This case study uses spectrogram technologies to provide a more accurate analysis of tone as a prosodic feature. It also provides a model for studying tone as one of several interacting pitch phenomena in song.

Praat was used to model the tonal features of Zulu song prosody from a database of several hundred songs. These songs provided the empirical basis for the study and were recorded over an extensive period of fieldwork in KwaZulu-Natal, South Africa, from December 2011 through December 2012. A wide range of traditional and neo-traditional genres of Zulu music were recorded for comparative purposes, including: isicathamiya, maskandi, afro-gospel, wedding and dance songs, and praise poetry. The results suggest that speech tone is one of several music-linguistic factors that impinge on melodic design and that its role fluctuates depending on context.

[1D-1.1] The acquisition and validation of large web-based corpora

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One of the central difficulties in the world of computational musicology and corpus studies has consistently been a frustrating lack of large amounts of data. While the tools to perform highly sophisticated analyses on large corpora of music have now been around for decades, many scholars are hesitant to invest the startup time required to create a large database of musical works. As such, many corpus studies have often relied on the repeated use of a limited number of databases, such as the Essen Folksong collection (Shaffrath, 1995), or the scores encoded at CCARCH). In this paper, we discuss issues pertaining to the acquisition and validation of a large web-based dataset. In this study, we analyze the corpus from the Classical Music Archives website, comprising approximately 14,000 MIDI files. MIDI files provide notoriously messy data from a symbolic notation perspective, and so it is important to validate the corpus in concordance with published scores. The authors randomly selected four measures from 400 pieces and visually compared PDF versions of the files against published scores. Twelve possible types of errors were identified, including errors in pitch-class, enharmonic respellings, rhythmic errors, bar-line alignment, etc. Data analysis is ongoing and will result in error rates for each of the twelve types of errors. The proposed dataset is a potentially fruitful source of corpus analysis. Reliable results, however, are contingent upon trustworthy data. By validating this corpus, our aim is to provide a reliable source of new studies in music analysis.

[1D-1.2] Why do listeners disagree about large-scale formal structure? A case study

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While empirical studies of how listeners segment a piece of music naturally focus on listener agreements, we argue that it is equally important to focus on the differences: for example, where do listeners perceive section groupings and section boundaries differently, and why do such disagreements arise? Probing deeper, we may ask: what factors can lead to differences in opinion among listeners, and how do these factors influence the analyses?

We conducted a case study in which we contrasted structural analyses given by two listeners, the first and second authors, of three performances. These performances were duets improvised by the second author and Mimi (Multimodal Interaction for Musical Improvisation), a system for human-machine interaction that allows the human user to briefly anticipate the machine's musical contribution. As listeners we also provided written justifications for the main features of our analyses. We then compared our analyses, exhaustively enumerating the differences between them and accounting for each.

We identified two proximate causes of most disagreements: paying attention to different musical features, and constructing different musical primitives—i.e., deciding what the fundamental structural units of the piece are—in the piece's opening moments. We posit that these disagreements in turn depended on two underlying differences between the listeners: our differing levels of familiarity with the performance, and our differing a priori expectations for the analyses.

We conclude that to better understand how listeners perceive the large-scale organization of a piece of music, we should study how a listener begins to form musical abstractions in a piece's opening moments, and how this process may be affected by the experience and expectations of the listener.

[1D-1.3] The tale of forty cities: The effect of population density on preferred tempo

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The effect of urban density on the behavior of a city's inhabitants has been studied extensively for decades. For example, Bornstein and Bornstein (1976) famously studied the rate at which people walk in both urban and rural areas, and found that urban dwellers tend to walk at a much faster pace than those who live in rural areas. Similarly, Hewlett and Rendall (1998) demonstrated that urban dwellers exhibited a faster speaking rate when conversing than did their rural counterparts. Van Noorden and Moelants proposed a "resonance theory of tempo perception," which stated that movement is correlated with tempo perception (1999) and later found a connection between natural body movement and tempo preference (2002). It might therefore be hypothesized that inhabitants of cities with higher population densities would prefer listening to faster music.

This paper examines the role of population density on tempo preferences in cities of varying sizes. It employs the Last.fm application programming interface (API) to collect the most commonly played songs during two randomly chosen weeks. The twenty most popular songs from 40 American cities and towns were retrieved, and the tempo of each piece was independently determined by participants. In order to further explore the relationship between environment and musical preference, a number of other factors such as average climate, average physical activity, and median household income were also included in a multiple regression analysis. Although data is currently being analyzed, results from a pilot study were consistent with our hypothesis. In examining the relationship between population density and listening habits, this paper provides both an analysis on the role of urban environments on musical preference, and offers a model for how digital means of acquiring data can be utilized to facilitate music research.

[1D-1.4] Employing music perception mechanisms in brain data sonification

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Visualization has recently become an important aspect in neuroscientific data mining. Even more recently, there were proposed ways to auditorily represent, or sonify, data to discover certain patterns, particularly in time series analyses. Here, we propose a procedure to musically represent input data patterns in the way perceptually and musically relevant to the listener, and provide quantitative metrics to evaluate these musical representations.

An example neuroscientific dataset was obtained from a BCI competition website (http://www.bbci.de/competition/iii/desc_V.html). We used Common Spatial Patterns (CSP) as implemented in BCILAB (http://sccn.ucsd.edu/wiki/BCILAB) to identify changes between brain states. Musical sequences corresponding to each of these states were obtained by extracting individual bars from a famous classical piece, and arranging these bars in qualitatively defined perceptual sequence (from more dissonant and sad through neutral to more consonant and happy). Two metrics were applied to quantify this arrangement: Percentage Similarity to harmonic series (PS; Gill & Purves, 2009) and Multiscale Entropy (MSE; Costa et al., 2005; Vakorin et al., 2012).

The resulting musical sequence was synchronized with the visual output to increase perceptual interpretability of brain states. Sadder and more dissonant bars had lower PS ($R^2 = 0.39$) and higher MSE curve integral ($R^2 = 0.76$) than happier and more consonant bars.

Key contributions of this study are:

- Efficient data sonification algorithm is provided–in addition to visualization, this feature is potentially relevant also for visually impaired users and for teaching purposes;

- Two independent quantitative metrics support a qualitative evaluation of musical excerpts with regard to their consonance/dissonance–this asset provides new exciting ways to statistically evaluate data related to music perception.

[1D-2.1] The effect of musical metre on beat synchronization and perception of beat alignment

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Western adults with no formal music training have implicit knowledge of the structure of music within their culture, and can synchronize their movements to a musical beat. Research with 12-month-old Western infants and adults has demonstrated a perceptual advantage (Hannon & Trehub, 2005) for simple metrical structures over complex structures. Here we test Western children's ability both to entrain with and to perceive simple metrical structures typical of Western music as well as less familiar complex meters.

We examined Western five-year-olds' perception of whether a drumbeat was correctly aligned to a musical excerpt (following Iversen & Patel, 2008), and their ability to synchronize their tapping to those excerpts. In the perception task children watched two videos, each of a puppet drumming along to a short musical excerpt, and gave the prize to the puppet that drummed better. One puppet drummed in synchrony with the beat of the musical excerpt, and the other drummed either out of phase or out of tempo relative to the beat. In the synchronization task, children tapped along to a metronome or along to the beat of the same musical excerpts used in the perception task. Excerpts had either simple or complex metric structures.

Data collection is ongoing. Results from pilot data suggest that children exhibit greater sensitivity to beat alignment when listening to excerpts with simple metres. Children selected the puppet whose drumming was correctly aligned significantly more often than predicted by chance when the excerpts were in simple metre, $p<0.01$, but not when they were in complex metre, $p=0.73$. We expect that perception and production will be correlated, such that five-year-olds' who are better able to perceive tempo and phase misalignments are also more accurate at drumming to the beat of a musical excerpt.

[1D-2.2] The role of expertise in the perception of timing: A reliance on motion

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We investigated the role of musical training by comparing the performance of TorQ–an acclaimed professional percussion ensemble – with the performance of nonmusicians on a sensorimotor integration task. Given previous research demonstrating musicians generally exhibit lower thresholds for perceiving timing deviations in simple rhythmic sequences than nonmusicians (Ehrlé & Samson, 2005; Madison & Merker, 2002), we anticipated the professional percussionists would perform better overall. However, we were interested in exploring whether they also exhibit stronger sensorimotor integration as well as a result of their lifetime of drumming experience.

Our task involved detecting temporal deviations to an isochronous sequence while moving along or remaining inert. Participants listened to an isochronous sequence and identified whether a final tone was on time with the established beat or not. On half of the trials the final beat occurred on time, and on half of the trials the final beat occurred slightly late. Participants either tapped along with the sequence (movement condition) or listened without tapping (no-movement condition). Overall, both groups performed significantly better when moving than when listening alone. Although the percussionists performed significantly better than nonmusicians in the timing detection task in the movement condition, when forced to remain still in the no-movement condition their performance was actually worse in some conditions. This raises interesting questions about the degree to which percussionist expertise in timekeeping is dependent upon motion. These findings complement the musical expertise and timing perception literatures by demonstrating that individuals with high levels of musical experience may actually rely more heavily on body movements when timekeeping than individuals with lower levels of experience.

[1D-2.3] Body and breath entrainment in the solo response project

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What is reliable in our physical responses to the music we listen to? How can we capture participants' engagement with music at it unfolds? The solo listening project is a case study in continuous responses to music. In it, one subject, the author, under took 24 listening sessions to a randomized playlist of 25 stimuli while recording several physiological measures of response and rating felt emotion. The stimuli were pieces of two to six minutes in length, ranging widely in emotional expression and genres with pieces by the likes of Alarm Will Sound, Gorillaz, Anonymous 4, and Nina Simone. Aligning the recorded measures per stimulus exposes two distinct types of physical entrainment: head nodding and synchronised breathing. The more hoppin' stimuli, such as bluegrass, hip hop, and rock excerpts, showed temporal precision in head nodding, a behavior which is typical for these styles. Though head-nodding was performed consciously by the subject when the music felt right, stimulus-synchronised breathing was not an intentional behavior. The western classical excerpts and vocal-centric tracks showed more coordinated breathing. Some tracks present a mixture of both breath and head nodding coordination, but hardly ever did they occur simultaneously, suggesting that these modes of entrainment are exclusive.

[1D-2.4] Audiovisual facilitation of sensorimotor synchronization

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Based on evidence from cognitive neuroscience that the sight and sound of others' rhythmic actions engage an automatic observation-execution matching mechanism (mirror neuron system), we tested the hypothesis that synchronization with a beat involves the simulation of those movements that give rise to it. In Experiment 1, dyads tapped a beat together under audio-alone (A), visual-alone (V), and audio-visual (AV) feedback conditions. Contrary to several previous findings involving artificial V stimuli, V was significantly more accurate than A, suggesting synchronization is aided by visual biological motion cues. In addition, AV was significantly more accurate than V and A, and the tendency in all three conditions for dyads to mutually "copy" small timing deviations in each other's previous beat was stronger for AV. These findings are consistent with reports of additive effects of AV biological motion on mirror-neuron system activity over A and V stimuli. Follow-up single-participant experiments further probed the AV advantage for synchronization accuracy under more controlled conditions. Applied and theoretical implications of these findings are discussed.

[1D-3.1] Pitch matching, melodic singing, and vocal-motor control

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Poor singing ability can be caused by poor pitch perception or by poor vocal-motor control. Many prior studies have tried to examine this relationship, but one factor that often fails to be taken into account is the timbre of the target to be matched. Here, we compare accuracy in instrumental and vocal pitch matching paradigms, designed such that each participant's own voice serves as both the target and the response. Participants (nonmusicians) matched their previously recorded voice on a slider, designed to play back their voice at different pitch levels depending on the location of a finger press on a continuous dimension. They also matched single pitches with their voice, and sang a familiar melody ("Happy Birthday") for comparison to the single pitch matching tasks. The nonmusicians were significantly better at instrumental pitch matching than vocal pitch matching, indicating that vocal-motor control is an important limiting factor on singing ability. There were significant correlations between the melodic singing ability and vocal pitch matching, but not instrumental pitch matching. People with higher quality voices tended to be more accurate with pitch in melodies. These results demonstrate that single pitch matching tasks can be useful in measuring general singing abilities, and further confirm the importance of vocal-motor control in determining singing ability.

[1D-3.2] Auditory ensemble coding: An efficient mechanism for perceiving tone sequences

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Humans frequently encounter ensembles or groups of sensory stimuli (e.g., people in a crowd, cars in traffic, performers in a band, notes in an aria) and are able to quickly process them with ease. However, rapidly combining numerous features into a coherent percept is an incredible computational feat. To accomplish this in vision, humans use summary statistics (e.g., average size, color, facial expression, etc.) to quickly perceive the "gist" of groups of features, presented either simultaneously or sequentially. In a recent paper (Piazza et al.,2013), we demonstrate that ensemble coding is also important for auditory perception, in particular for summarizing pitch information from tone sequences over time. Listeners could accurately estimate the mean frequency of a set of logarithmically-spaced pure tones presented in a temporal sequence, but their performance was severely reduced when only a subset of tones from a given sequence was presented, demonstrating that ensemble coding is based on integration of a substantial number of the tones in a sequence. This precise ensemble coding occurred despite very limited representation of individual tones from the sequence: listeners were poor at identifying the pitch of specific individual member tones and at determining their positions in the sequence. Our sequences had a whole-tone structure and thus did not belong to a single major or minor key. This suggests that, like hierarchical pitch schemas for tonal music, statistical representations also guide the perception of sequences that are not traditionally tonal. We are also investigating the time scale of this phenomenon and examining which types of rhythmic structures are optimal for generating robust summary statistics. Overall, our results indicate that summary statistical coding is important for extracting ensemble information not only from visual scenes but from auditory ones as well, and likely reflects a more generalized perceptual mechanism in the brain.

[1D-3.3] Absolute pitch may not be so absolute

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Most people cannot name the musical note that corresponds to a particular pitch, but for those people with absolute pitch (AP) musical notes can be accurately identified on hearing a pitch. For this rare ability, early experience during a developmental period is often thought to convey category identity and stability, but the plasticity of AP musical categories has not been fully investigated. Here we show the first evidence that, for adults, AP note categories can change with listening experience. When exposed to approximately 45 minutes of music detuned by a fraction of a semitone (33 cents), AP participants show shifts in perception in direct accord with this experience. Specifically, after this detuned listening experience, AP possessors rate flat notes as more "in-tune" than in-tune and sharp notes and this effect appears to remain stable throughout the duration of the experiment. This suggests that the apparent stability of absolute pitch categories is thus not conferred by early experience but instead by the cultural norms adopted for tuning music.

[1D-3.4] Short-term memory for serial order of timbre

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The exploration of musical timbre has undisputedly been one of the driving forces of the evolution in music composition and production in the 20th and 21st centuries. Nevertheless, there is very little work which addresses in detail the cognitive capacities for the processing of sequential timbral structures, which would be essential for the apprehension of musical phenomena as divers as orchestrations of Klangfarbenmelodie (timbre-melody), sound sampling, or drum or percussion tracks, to name a few. In order to develop a psychological foundation for a theory of orchestration, a deeper understanding of listeners' abilities in learning, memorization and recognition of timbral sequencing rules and their transformations is of crucial importance. In this study, we considered the fundamental faculty of short-term memory for serial order.

We investigated the influence of a) sequence length with 4-6 elements, b) pitch variability within sequences, and c) mean perceptual dissimilarity of timbres, using the timbre-stimuli and dissimilarity data from McAdams et al. (1995, Psych. Res.), as independent variables in a within-subjects design. Testing n=30 musician subjects, we obtained effects of length and mean timbral dissimilarity on the accuracy of order-discrimination, but no effect of pitch-variability. The data also featured a positive linear dependency between accuracy and timbral dissimilarity of items whose serial position had been switched. Mean confidence ratings, however, did not seem to be related to accuracy.

These findings stand in contrast to those of Schulze and Tillmann (Memory, 2013) who did not observe an effect of length using a similar paradigm while comparing memory for sequences of tones, timbres and words in non-musicians. Our results further suggest partial independence of timbral order from pitch processing and highlight the role of implicit cues for auditory sequence memorization. Finally, the data suggest that the validity of a multidimensional scaling based timbre space model generalizes to more complex cognitive tasks such as auditory sequence memorization.

[1D-4.1] Music and the web of belief

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Starting from a position of naive naturalism, this study offers a formalized application of the Quinean notion of webs of belief in the context of musical thought, allowing for an empirical investigation of music perception free from ontological commitments to objects in tonal and pitch class theory. That is: It allows for the design and analysis of experiments which investigate music qua music as opposed to through the prism of interpreted tokens which are not elements of normal musical perception.

The method, which has been previously outlined by the author (following the definition of musical gesture posited by Robert Hatten), is here re-derived from first principles, and presented in the form of analytical tableaux which may be tested either forwards, backwards or for internal validity and consistency. In this way the experimenter can investigate how a musical whole is constituted by musical elements and what the logical relationship between those elements are without having to commit to an a priori interpretation of either the elements themselves or a particular schema for how the logical connectives are employed.

Aside from being motivated by the desire to produce a strong systematic analytic tool which accurately reflects how music is perceived rather how it is disseminated through notation, this method also has the broader aim of rehabilitating musical conception as an integral part of human thought in a modal framework in contrast to the modular mind theories which often relegate music to the role of "auditory cheesecake." This broader topic will be broached through a modified, quasi-Hegelian, version of Quine's indispensability argument.

Taken together, success in attaining these goals would imply that it is not only possible to study music experimentally in an objective, non value-laden manner; but also that such study has a central role in the study of human cognition.

[1D-4.2] What makes a siren sultry: Investigating the roles of the attractiveness stereotype and risk regulation in vocal performance evaluation

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Physical attraction has been linked to greater success across many situations from job interviews to political campaigns, but to what extent does physical attractiveness influence vocal performance evaluation? Prior studies have evaluated attractiveness of the spoken voice, but research into the impact of physical attraction within a vocal music context is limited. To date, it is known that vocal tone is the key factor in perceived auditory attractiveness. The current work builds from this finding to examine the influence of evolutionary theories of attraction and risk regulation on rating of vocal evaluation and target desirability.

In the current study, 88 college-aged, American adults rated vocal skill and vocal attractiveness of a series of pictured individuals. Each picture was paired with a separate soprano female vocal recording of a fragment of The Star Spangled Banner. Unknown to participants, one voice was presented twice with different pictures. The first picture had been rated as high in attractiveness and second had been rated as low in attractiveness. The two recordings paired with these pictures had varying diction, rhythm, and ornamentation, but maintained the same tone quality.

In order to examine risk regulation, half of our participants were asked to write about a rejection experience at the beginning of the study, the other half wrote about an acceptance experience. Significant findings bridge previous work on evolutionary theories of attraction and risk regulation by showing that the accepted male participants favored the voice paired with the more attractive picture, while rejected males gave both voice recordings the same attractiveness rating. As predicted, female participants' ratings were not impacted by the attractiveness stereotype.

[1D-4.3] Can pianists hear timbres? Perception and verbal-label identification of performer-controlled piano timbre nuances

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Timbre expression is essential in virtuosic piano performance. Performer-controlled timbre is described among professionals with imaged, qualitative terms, as advanced-level piano teaching is essentially devoted to the transmission of abstract concepts directly linking timbre expression to the character and emotion it ought to instill.

Nevertheless, even in this qualitative frame, highly-skilled pianists seem able to avoid inter-individual misunderstandings in timbre description.

This study aims at examining the consistency in the understanding of piano timbre, from verbalization, to production, to perception and to verbalization, by exploring whether pianists can identify a timbral nuance in audio recordings and label it with the descriptor corresponding to the performer's timbral intentions.

In this aim, four short pieces were composed that could each suit the expression of five different timbral nuances corresponding to the most common and representative descriptors: Bright, Dark, Dry, Round and Velvety. Three professional pianists were asked to perform each piece in these different timbral nuances. Sixty audio performance recordings were then used as stimuli in a perception test, wherein participant pianists were asked to assign one of the five timbre descriptors to the stimuli.

Preliminary results over 15 participants show a 0.627 overall correct verbal-label identification rate, which supports the hypothesis of consistency in verbal description between the production and perception of piano timbre. Identification was significantly above chance for every participant.

While significant effects of stimulus performer and timbre were found, identification rates remained significantly above chance for each stimulus group.

Further results shall be compared with the quantitative descriptions of these piano timbre nuances, explored separately according to their production, gestural control, and acoustical features. A better understanding of the perception and verbal-label identification of piano timbre may be applied to refining advanced-level pedagogical methods, and to improving the possibilities of timbre expression in piano software modeling.

[1D-4.4] Diatonic semitone tuning in two-part singing

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This study examines the impact of context on melodic semitone intonation in two-part singing by asking singers to perform a short semitone pattern against a variety of contexts provided by a manipulated prerecorded accompanying voice. This builds on work done by Vurma (2010), who studied singers' intonation using an exercise that included an isolated ascending and descending semitone. The singers performed against a synthesized accompanying line, which was presented either in equal temperament or detuned by 20 or 40 cents. Vurma found that the singers retained relatively consistent melodic intervals despite the different tuning conditions, averaging 100 cents (SD=14). The isolated melodic segments in Vurma's exercise lacked any implication of musical context and the amount of detuning was arbitrarily selected without regard to historically relevant tuning systems. Our experiment seeks to explore melodic semitone tuning in a more ecologically valid context.

The subjects, six professional and six non-professional singers, were asked to sing a short diatonic semitone pattern against manipulated versions of 15 different recorded bass lines. The lower line was transposed using pitch correction software to two different pitch levels (starting on G and Bb), and retuned according to three different conditions (equal temperament, Just Intonation, and a modified version of Just Intonation with certain notes raised or lowered by one or two syntonic commas). The subjects were given a musical score so that they could see the notes sung in the accompaniment.

Our preliminary results show an overall average melodic semitone size of 85 cents (SD=21). Statistical analysis showed significant effects for intervallic direction, training, transpositional level, and for vertical octaves versus other intervals. There were no significant effects from detuning the lower line. Ultimately, the results of this study will be useful for understanding the interaction between melodic and vertical intonation in flexible-pitch ensemble performances.

Poster Abstracts

[1-01] Exploring negative musical response

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Although negative responses to music are common (Craton et al., 2008; North, Hargreaves, & Hargreaves, 2004), we know little about the nature of these responses (Craton & Lantos, 2011; Lantos & Craton, 2012). We employed a repeated taste-test paradigm (Ritter & Preston, 2011) previously used to measure disgust and other emotional responses to non-musical stimuli. Participants (Experiment 1, N = 55; Experiment 2, N = 30) rated a drink and their mood before and after tapping in synchrony with disliked music. To avoid participant bias, we told them the cover story that the beverage/mood ratings and the tapping task were for two separate studies: a "consumer survey," and a "rhythm perception experiment."

Participants in the universally-disliked condition tapped to music that had been composed to be unpleasant to all listeners (The Most Unwanted Music, Komar, Melamid, & Soldier). Those in the individually-disliked condition tapped to heavy metal music (Experiment 1: Metal Health--Bang Your Head, Quiet Riot; Experiment 2: Take This Life, In Flames) which they were expected to dislike based on their prescreening responses on the Short Test of Musical Preferences (STOMP; Rentfrow & Gosling, 2003). Participants in the neutral condition tapped to a new age composition (By the Seashore, Robert Norton).

Disgust ratings for the beverage were not affected by exposure to disliked music in either experiment. Active mood ratings (Exp 1) decreased more in the universally-disliked (M difference = 1.17, SD = 1.47) than in the neutral (M = 0.06, SD = 0.64) condition, $t(23.2) = 2.95$, $p = .007$. Sadness ratings (Exp 2) increased more in the neutral (M = -0.40, SD = 0.52) than in the combined disliked music (M = 0.05, SD = .39) conditions, $t(14.4) = 2.43$, $p = .029$. These findings provide a first step in characterizing negative musical response.

[1-02] Emotional response as a metric for music reception

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The degree to which a listener perceives music can be reflected in the extent of the listener's emotional response. In the case of listeners with hearing loss, the range of their emotional response to music may be useful as a metric of their ability to perceive music through impaired ears. In this study, we evaluated a paradigm for measuring real-time emotional response to music as a means for characterizing listeners' music reception.

In our paradigm, listeners report the expressed emotion in music using the *affect grid*, a two-dimensional map of emotion with valence represented on the abscissa and arousal on the ordinate. The goal of the first phase of the study was to examine if acoustic manipulations intended to capture some effects of hearing loss would be reflected in the reported emotion contours of normal-hearing listeners. A second phase of the study was conducted to examine whether consistent data could be collected for establishing baseline conditions using crowdsourcing techniques. For this second phase, we employed Amazon's Mechanical Turk as a means for collecting data from a large number of listeners.

Initial results show that, while there is considerable variability across listeners, general music features are well represented in subject responses. Manipulations intended to represent hearing loss show a reduction in responses for some listeners, suggesting further work in this area may be fruitful. Finally, crowdsourcing results show that, even under less-controlled settings, listeners are consistent in their responses and this paradigm appears to be a viable means for collecting baseline normative data on the emotional response evoked by music. Collectively, our results suggest that this new paradigm could be developed into a useful metric for the evaluation of assistive devices designed to restore music perception in listeners with hearing loss.

[1-03] The voice of silent films: Passing affective information from sight to sound

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Research on multi-modal perception provides support for the hypothesis that visual information can influence aural experience (McGurk, 1976; Shutz & Kubovy, 2009). Here we researched visual information influencing affective auditory processing, specifically emotional coding, by investigating the influence of positive or negatively valenced film clips on emotionally "neutral" music. In a pilot study, several composers created solo piano pieces that they considered to be emotionally neutral. For the aforementioned follow up study, these neutral scores were then paired with positively or negatively valenced silent-video clips. Participants were exposed to several combinations of valenced film and neutral music. After a short distraction test, participants listened to the music used in the experiment once again, this time without the accompanying visual information. Participants were then asked to rate the valence and arousal of each recording. The results will test the hypothesis that extra-musical associations from silent-films can influence perceived emotional affect in music.

[1-04] Consistent emotions? The relationship between written and performed tempos in J. S. Bach's Well-Tempered Clavier, Book I

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Both timing and mode are known to play a role in the perceived emotion of a composition, and their effects are strongest when used in conjunction. Here we explore the issue from a novel viewpoint by examining individual differences in the tempos of 13 performances of the complete set of J.S. Bach's *Well-Tempered Clavier* (Book I). Specifically, we ask whether the major key (nominally "happy") pieces are faster than their minor key (nominally "sad") counterparts. This study extends our lab's previous work on timing as a cue for emotion (based entirely on *notated* scores) within this corpus by exploring timing's prevalence in *performances*. Our aims are threefold: (1) to examine individual differences in the interpretation of performance tempo; (2) to explore the relationship between performed tempos and how they reflect notated tempos; and (3) to discern how this information interacts with previous findings on notated tempos.

The data set consisted of the tempos from 24 preludes and 24 fugues in each of the 13 performances (7 piano, 6 harpsichord), using an existing treatise by noted musicologist Willard Palmer (1981). Our analysis revealed that the differences in tempo between major and minor key pieces, previously observed in notated editions of the collection, were replicated. In fact, the median major key tempos were faster than their minor key counterparts *for each of the thirteen performances*. This consistency is surprising given the considerable variations in tempos between different performers. This outcome complements previous research on differences in the use of timing in major and minor key pieces in Bach's *Well-Tempered Clavier* (Book I) focused exclusively on written scores studied by our group (Poon & Schutz, 2011) as well as others (Horn & Costa-Giomi, 2011).

[1-05] Mu wave desynchronization during emotion judgments of human song

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The mirror neuron system (MNS) has been implicated in the understanding of movement intentions, and is thought to be integral to the experience of empathy. It has been implicated in emotion perception during song and speech (Molnar-Szakacs & Overy, 2009). However, it is unknown whether the MNS plays a special role in perception of emotional movement as compared to non-emotional movement. In our study we showed participants identical stimuli (sung musical intervals) and asked them to make either an emotional judgment about these stimuli (positive vs. negative valence) or a structural judgment (large vs. small pitch distance). The mu wave, an index of MNS activity, was used to assess differences between the two judgment conditions. Preliminary findings suggest the presence of activity generated from a left central brain cluster that is greater for emotional judgments than for pitch distance

judgments in the mu frequency ranges of 8-13 Hz and 15-25 Hz. This pattern of findings suggests that this area may exhibit greater involvement in emotional judgments of movement than non-emotional judgments, and may be indicative of mirror neuron activity. Other clusters were found that generate greater pitch distance-specific activity. The activity of various clusters and their implications will be examined.

[1-06] Awe struck: How the perception of virtuosity influences listeners' emotional reactions

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Music listeners frequently express feelings of awe at the skills of performers. Indeed, great technical skill, extreme vocal range, and improvisational prowess are considered crucial elements in many musical styles and a sense of wonder evoked by performers' incredible, perhaps mysterious and 'magical,' abilities may be an important emotional trigger for listeners of these styles. In this study, an experiment will be conducted to measure the impact of listeners' perception of performers' skill on the listeners' emotional responses to music. The experiment is conceived as a between-subjects design. Two groups of participants will be exposed to identical sets of virtuosic musical passages and asked to rate the strength of their emotional response to the passages using the Geneva Emotional Music Scale-45 (Zentner M, 2008), how much they enjoy the music, and what they judge the overall quality of the music to be. The independent variable will manipulate participants' perception of the performers' skill level. For group one, the skill of the performer will be downplayed, for instance by suggesting that the musical excerpt is precomposed, rehearsed, edited or otherwise fixed via 'studio magic,' to fake a virtuoso performance. For group two the skill of the performers will be highlighted, for instance by suggesting that the musical excerpts are live, fully improvised, unedited performances. To avoid demand characteristics, the independent variable will be hidden among other extra musical information, acting as lures, in accompanying 'liner notes.' Our hypothesis is that participants who believe the performances to be virtuosic will have stronger emotional responses and enjoy the music more. The musical preferences of the participants will also be collected in order to determine if listeners' preferences correlate with their responses; for instance, Jazz listeners may strongly prefer improvised music to composed music. Data is still being collected.

[1-07] Improving specificity of musical mood induction

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The study seeks to validate a set of musical pieces for the purpose of mood induction by evaluating the physiological and subjective emotional changes caused by the music. In an attempt to improve the specificity of available mood induction procedures, the study looks at three distinct negative moods: tiredness, sadness and anxiety. These moods are often clustered together under the broader category of negative affect. However, they exhibit unique subtle differences in terms of valence and arousal and have markedly different effects on behavior and cognition (Wehmer and Izard, 1962; Izard, 1964; Wessman and Ricks, 1967, as cited in Forgas, 1995; Bar-Haim et al, 2007; Sarason, 1990; Montgomery, 1983). Participants in the study listen to one of 18 film soundtrack excerpts, equally divided across the three mood categories. Subjective responses are quantified using a Visual Analogue Scale (VAS) to assess tiredness, sadness and anxiety as well as a Self Assessment Scale (SAM) to assess valence and arousal. Peripheral physiological measures include heart rate, respiration, galvanic skin response, and surface electromyography (zygomatic and corrugator). Data for all measures is based on the last 10-second window of the listening period, minus the baseline window. One-way ANOVAs will be used to examine whether the subjective and physiological responses caused by the music differ significantly between conditions. While data collection is at its early stages, preliminary findings indicate unique physiological and subjective profiles for each of the mood conditions. Data collection and analysis are expected to be complete by June, 2013 and will include a sample of 180 participants (60 in each of the mood conditions). Once validated, the music selections used in this study will serve as a database for mood induction of tiredness, sadness and anxiety, applicable to a variety of research disciplines, such as social, personality and clinical psychology.

[1-08] Studying the effects of high and low arousal music on memory consolidtion

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The arousal hypothesis states that an arousing event elicits physiological responses that endure beyond the arousing event, and that the strength of these responses influences the consolidation of newly acquired information (Judde & Rickard, 2010; Nielson & Powless, 2007; Nielson, Yee, & Erickson, 2005). Musical study of the arousal hypothesis has investigated whether or not emotionally arousing music can alter long-term memory consolidation. Although previous research has found that arousing music has some ability to modulate long-term memory consolidation, the physiological basis of this effect has not been corroborated (Judde & Rickard, 2010). To better understand this phenomenon and to test the arousal hypothesis directly, we are examining the effect of high- and low- arousal music on participants' memory scores, while monitoring skin conductance levels (SCL), photoplethysmography (heart rate) and electromyography (facial movement). We hypothesize that high arousal music will elicit better memory scores and higher SCL than low arousal music. Furthermore, we expect that memory scores will be correlated with the baseline-corrected SCL. Participants were given a list of words to remember, and were presented with happy, agitated, sad, or peaceful music. Memory of the word list was tested one hour and one week later. The arousal hypothesis was not supported as no arousal or memory effects were found. Despite these results, it is believed that the arousal hypothesis still provides a compelling explanation for long-term memory effects when listening to music. It is hypothesized that the lack of significant results are due to methodological issues. A marginal valence effect between positive and negative valences at high arousal was also found, which is worth further investigation.

[1-09] Context-dependent memory: The effects of musical mood and arousal on memory performance

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Listening to music can enhance memory performance (Wallace, 1994). However, the cognitive mechanisms underlying the benefits of music are currently unknown. One explanation is that music establishes a 'context' that, when reinstated, cues memory (Standing et al., 2008). Two ways that music can establish context have been proposed: (1) by presenting the same piece of music at study and at test (Smith, 1985) or (2) by presenting the same mood (positive or negative) and arousal (high or low) at study and at test (Balch & Lewis, 1996; Mead & Ball, 2007).

Here, we examined how musical context affected memory performance. Participants performed a face-name association task while music was played in the background. Participants learned the face-name pairings during the study phase, and then immediately determined whether the face-name pairings in the test phase matched the study phase. The ways that music can establish context were examined in two separate experiments. In Experiment 1, participants either heard the same piece of music at study and at test, or two different pieces of music with the same mood and arousal levels. In Experiment 2, participants always heard two different pieces of music with either matched or mismatched levels of mood and arousal.

In Experiment 1, there were no significant differences in memory performance between the same music and different music conditions. In Experiment 2, there were also no significant effect of changing mood and arousal between study and test. The results of both experiments were inconsistent with previous literature. Perhaps the context effects of music may not generalize to associative memory paradigms since previous work has found robust effects of musical context on recall and recognition memory. Future work will compare the contextual effects of musical mood and arousal among different memory tasks (i.e., recall, recognition, and association).

[1-10] Music for solo performer by Alvin Lucier contextualized through current trends in brainwave sonification

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The sonification of brainwaves produced by analog electrical and acoustical sounds in *Music for Solo Performer* (MFSP) by Alvin Lucier, was both an attempt to bypass the acculturated frame of sound "I think that acoustical phenomena are universal, not cultural, so I decided...to explore the natural characteristics of sound waves" (Rogalsky, 2010) and also a door through which we might hear the sound of alpha brainwaves in process as music. MFSP poses an audacious challenge to conventional musical analysis; while normally a main goal of musical analysis is to address the mind of the composer or performer, how do we analyze the sonic projection of a (largely involuntary) waveform occurring in the electrical pattern of the brain? Although the piece would seem to be angled specifically to transcend normal "musical meaning" and address 'state of mind' itself, Alvin Lucier says, "I found the alpha's quiet thunder extremely beautiful" (Lucier, 2007, track 2). We can explicate that beauty through a sonic and musical analysis. Lucier has provided us with a way to evaluate aesthetic judgment itself in its most raw state.

From the structural and surface differences between various versions of MFSP and it's relation to other 'brainwave music' we can ask the question, which criteria can we use to assemble the most meaningful musical "translation" of brainwaves? To that end, first I compare all the available recordings of MFSP to each other. Thereafter I discuss recent neurological research in the realm of sonification, both medical and aesthetic and see how a close reading of Music for Solo Performer can both enliven and inform the current discussion.

[1-11] Thalamic multisensory integration: Creating a neural network map of involved brain areas in music perception, processing and execution

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Music activates a wide array of neural areas involved in different functions besides the perception, processing and execution of music itself. Understanding musical processes in the brain has had multiple implications in the neuro- and health sciences.

Engaging the brain with a multisensory stimulus such as music activates responses beyond the temporal lobe. Brain networks involve the frontal lobes, parietal lobes, the limbic system such as the Amygdala, Hippocampus and thalamus, the cerebellum and the brainstem. Nonetheless, there has been no attempt to summarise all involved brain areas in music into one overall encompassing map. This may well be, as there has been no thorough theory introduced, which would allow an initial point of departure in creating such a atlas.

A thorough systematic review has been therefore conducted together with functional magnetic resonance imaging (fMRI) to identify all mentioned neural connection involved in the perception, processing and execution of music.

Tracing the direct responses in the involved brain regions back to its origin (the incoming stimulus through the cochlea), neural tracks lead nearly exclusively via the thalamic nuclei. Communication between the thalamic nuclei is the initial step in multisensory integration, which lies at the base of the neural networks as proposed in this paper. Against this backdrop, this manuscript introduces the to our knowledge first thorough map of all involved brain regions in the perception, processing and execution of music, out of the general need of such a map and the knowledge, which can be gained from it.

Consequently, placing thalamic multisensory integration at the core of this atlas allowed to create a preliminary theory to explain the complexity of music induced brain activation, ergo a consecutive network encompassing and explaining the connections between all areas and not only areas of interest in the singularity of different strains of music related research.

[1-12] A systematic review on the neural effect of music on emotion regulation: Implications for music therapy practice

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Emotion regulation (ER) is an internal process through which a person maintains a comfortable state of arousal by modulating one or more aspects of emotion. The neural correlates underlying ER suggest an interplay between frontal lobe areas involved in cognitive control and areas involved in emotional reactivity. One medium long thought to have an impact on emotions and ER is music. However, although the music neuroscience literature is increasing, there is little that explores the connection between music and ER processing.

The objectives of this review were to examine the effects of music on neural structures implicated in ER and to create preliminary clinical considerations for structuring the music stimulus when facilitating ER. A comprehensive electronic database search resulted in 50 studies that met predetermined inclusion and exclusion criteria. Pertinent data related to the objective was extracted and study outcomes were analyzed and compared for trends and common findings.

Results indicated that there are certain musical characteristics and experiences that produce desired and undesired neural activation patterns implicated in ER. Desired activation patterns include listening to music considered pleasant or happy and when singing; undesired activation patterns arose primarily in the amygdala when introducing complexity, dissonance, and unexpected musical events. The connection between music-influenced changes in attention and it's link to ER were explored. Future research should include clearer, more detailed intervention reporting.

[1-13] The effect of Melodic Intonation Therapy on tongue-twister induced speech disfluency

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Melodic intonation therapy (MIT) has been evaluated as a treatment for non-fluent aphasia induced by brain injury. However, it has not been assessed as a treatment option for speech disfluency among typical speakers who experience fluency problems for particular words or phrases. In this study, we examined the effect of MIT and its individual components (melody and rhythm) on speech disfluency in neurologically intact individuals. Speech disfluency was induced using 10 tongue twisters that were created for the study. Seventy-one participants were randomly assigned to one of four treatment conditions: control (repetition), full MIT (intoning and left hand tapping), melody (intoning only) or rhythm (left hand tapping only). Each condition involved a pre- and post-treatment fluency assessment phase, and a training phase in which treatment was applied to the articulation of tongue twisters. Individual error-types and total error scores were analysed. The mean post-treatment disfluency scores on the trained tongue twisters were similar for rhythm (M = 28.2), melody (M =28.1), and control (M = 25.1), but reduced for MIT (M = 14.2), $t(67) = -3.37$, $p = .001$. However, subsequent analyses of (pre-post) difference scores raised questions about the reliability of this effect. Analysis of individual error-types revealed that, compared with fluency scores following other treatment conditions, MIT led to a significant improvement in fluency for a wider range of error types (e.g., vowel errors, repetitions, consonant errors, hesitations, etc.). We discuss the implications of these results for understanding how MIT can help to reduce disfluency for certain types of speech errors, regardless of whether speakers are neurologically impaired. The value of MIT for neurologically intact individuals may depend on the combination of melodic and rhythmic aspects of treatment, because these two components may jointly allow speakers to focus effectively on fluency during speech production.

[1-14] Music and language short-term training reveal brain plasticity in early childhood: One year follow-up

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Bilinguals and musicians have been shown to perform better than monolingual non-musicians in executive functions. For bilinguals, these findings have been attributed to their need to manage attention to two languages that are jointly available during linguistic performance. For musicians, these findings have been attributed to their training requirements involving intensive memorization and motor and attentional coordination. Here we tested the outcomes of music vs second-language learning to determine whether training can change sound processing and whether this change is domain-specific or transfers to other domains.

We used an intervention design with 36 English-speaking children, 4-6 years old, with no prior training (pre, post) and 30 children came back for one year follow-up. Groups were equated on age, IQ score and maternal education, and received computer-based music or French language training for one month. We measured ERP in the MMN paradigm while children were passively listening to music notes (A, A#) or French vowels (u, ou).

At post, both groups showed enhanced late difference negativity (LDN) in their trained task (note–Music 450-650 ms; vowel-French 650-850 ms) and reduced LDN in the untrained task. Increased LDN for the trained task accompanied by reduced LDN for the untrained task might reflect better processing of the relevant (trained) sound as a result of training while tuning out the irrelevant (untrained) sound.

One year follow-up results show enhanced mismatch negativity (MMN 175-225 ms) and LDN (450-600 ms) to the vowel sounds in the French group but not in the music group and a maintained LDN effect of the music training group in the note task suggesting a domain specific lasting effect following both trainings. These results show that a short period of music and second language training induced domain-specific and domain-general brain plasticity of sound processing in early childhood which last in time.

[1-15] The influence of background noise on the N400 is mitigated in musicians

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Semantic processing of a spoken word is related to an event-related potential, known as the N400. The amplitude of the N400 increases as the difficulty of matching the incoming speech sound to a stored semantic representation becomes more difficult. One way to increase the difficulty of semantic processing is to add background noise to the presentation of the word. Interestingly, musicians have an advantage in understanding speech-in-noise, and this advantage has been attributed to a more robust encoding of the speech signal when presented in noise at the level of the brainstem. It was expected that in musicians, this enhanced encoding would facilitate semantic processing of a word presented in noise. To test this possibility, we presented spoken words in three levels of multi-talker babble noise (none, 15, and 0 dB signal-to-noise ratio [SNR]), to musicians and non-musicians, in two listening conditions, while recording electrical brain activity. In the active condition, participants repeated the word aloud, while in the passive condition they watched a silent movie. Without background noise, the semantic content of a word can be processed with minimal demands on cognitive resources, but as the SNR decreases (noise level increases), greater attention-dependent processing is needed to determine the semantic content of the word. To isolate this attention-dependent activity, difference waves were calculated between the active (only to words repeated accurately) and passive listening conditions. This difference wave revealed an attention-dependent N400 wave in both groups. Critically, the amplitude of the N400 increased as SNR decreased in the non-musicians only. This finding suggests that musicians do not require additional attention-dependent cognitive resources to understand a word presented in background noise, while non-musicians do. Moreover, it supports the hypothesis that enhanced encoding of speech sounds at the level of the brainstem facilitates downstream semantic processing of speech in noise.

[1-16] Imitation and discrimination of the human voice

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The abilities to imitate and discriminate different aspects of the human voice are essential to both speech and music. Although it is natural to think that conscious perception must precede imitation, dual-route theories suggest that these functions may be controlled by different subsystems. This then suggests that highly-skilled performance, such as that of talented singers, may not depend on overt perceptual ability. We hypothesized that participants' abilities to imitate both subtle and large differences in speech and singing should be independent of their abilities' to discriminate the same differences. Our stimuli were created by continuous morphing between naturally-produced endpoints. The continua each had five points, and comprised gradual variations along the dimensions of vocal timbre, pitch, and phonetic category (both native and nonnative). Participants imitated each variation of each continuum, and made same / different judgments between pairs of continuum variations. Both tasks were performed while scalp potentials were recorded with continuous EEG. Our results show variability in the abilities to imitate and to discriminate different types of vocal changes. Each task type was also associated with unique electrophysiological effects. These findings can explain why some people are natural mimics, why others find it difficult to sing in tune, and why accent can vary so widely among second language learners with similar comprehension abilities.

[1-17] The role of distal prosody in learning words in an artificial language

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When learning a spoken language, listeners track distributions of speech sounds, and use transitional probabilities between syllables to identify word boundaries. Listeners also use local prosodic cues such as word-initial stress and phrase-final pauses to aid in word segmentation. Recent studies have shown that for a known language, listeners can use pitch and timing patterns occurring at the beginning of utterances ("distal prosodic cues") to segment speech material occurring later on in the utterance. The present study investigated whether distal prosodic cues can facilitate the learning of words in a novel language. To test this possibility, we implemented an artificial language-learning paradigm that manipulated distal prosodic cues while holding transitional probabilities between syllables constant. Listeners were exposed to 288 sequences of 9-10 syllables each where the 6th-9th syllables constituted disyllabic target words. For each syllable sequence, distal prosodic cues were either congruent or incongruent with the word boundaries of target words. After exposure, listeners heard 24 test items; half of these were target words heard during exposure and half were non-words. Of the target words, half had been heard with a congruent distal prosody and half with an incongruent distal prosody. For each test item, listeners judged whether the item was a word or a non-word in the artificial language using a 6-point confidence rating scale. If transitional probabilities alone were used to segment words during exposure, there should be no difference in the learning of congruent and incongruent words. However, if distal prosodic cues guided segmentation and facilitated word learning, listeners should better identify congruent items as words in the language than incongruent items. Consistent with a role for distal prosody in word learning, congruent words were learned better than incongruent words. Implications for understanding the relationship between music and language processing will be discussed.

[1-18] Singing and speaking have complementary but not identical effects on language acquisition

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Singing and speaking share neural networks and a common vocal apparatus. It has even been claimed that speech evolved from song. But are they equally efficacious for language learning? We examined this issue with an artificial language comprised of three word classes; ie-words (e.g., tisolie), o-words (e.g., hifto) and A-words (e.g., puser). In three study-test cycles, learners (Introductory Psychology students) heard and repeated sung or spoken sentences in the language and were tested for their ability to detect four types of rule violations in spoken sentences: A, Sentences must contain an o-word and ie-word (*hifto flengo); B, Suffixes cannot be interchanged (*hiftie tisolie); C, Sentences cannot start with an A-word (*puser hifto tisolie); and D, A-words can only follow o-words (*hifto tisolie puser). The duration of sung sentences was controlled to be equal or within 1-s of the corresponding spoken sentences. In the singing condition, the notes were cues to the dependency of the A-word on the o-word (o-words and A-words were sung as E3, F3, and/or G3; ie-words were sung as E2, or down a tone, as F2 to G2). Data collection is almost complete (currently, n=29). Logistic regressions with a logit link for binary data revealed the following overall pattern of erroneous judgments for the four rules: D > A = B > C. The frequency of erroneous judgments did not differ in the Speaking and Singing groups (Ms, 1.65 and 1.60), but Singing facilitated learning Rule A (Ms, 1.17 vs 2.29), whereas Speaking facilitated acquisition of Rule C (Ms, 0.71 vs 1.77). Thus, singing and speaking seem to have complementary functions, singing enhanced analysis of the syllabic structure of words whereas speaking enhanced perception of word order dependencies.

[1-19] Effect of melodic cues on learning the Korean dative

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We describe a new paradigm for examining whether melodic cues enhance learning grammatical rules, using Korean datives as an instance. Learners hear English double-object datives (e.g., *Dave sells Brad a book*), each one is followed by two Korean sentences. Both are grammatically correct translations of the English sentence but one has recipient-object (RO) order (as in the English example) and the other has object-recipient (OR) order. Two Korean verb classes were used, one contains the syllable "chu" as in "sa-chu-da" (buy), the other does not as in "po-ney-da" (send). Verbs with chu attach the suffix –ul to the recipient in ROs (Brad-ul) and the suffix -ekey in ORs (Brad-ekey), but po-ney-da verbs use –ekey in both ROs and ORs. In both classes, the object always occur with –ul as in chek-ul (book-ul). So *Dave buys Brad a book* would be followed by *Dave-ka Brad-ul chek-ul sa-chu-da* and *Dave-ka chek-ul Brad-ekey sa-chu-da*. The Korean sentences are presented in one of three conditions; monotone intonation, sentence intonation, and song (edited for equal duration of sentences in all conditions). In the song condition, the melodic contour differs distinctively in sentences with –chu verbs and sentences with po-ney-da verb types (i.e., melodic contouring is a cue to verb class differences). The syllables of each word are sung on the same note in ORs and ROs, so that the different pattern of notes in ORs and ROs is a cue to the word order and suffix differences. Following each of three blocks of 16 study trials with the same eight verbs (four in each class), participants are tested for their ability to differentiate between grammatical and ungrammatical sentences. We are currently piloting the methodology and anticipate having data for at least 15 participants by August.

[1-20] What is the relationship between music aptitude and musical experience?

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The performance of musicians and non-musicians has been shown to differ on cognitive tasks such as verbal memory (Franklin et al., 2008; Brandler & Rammsayer, 2003) and foreign language learning (e.g., Marques et al., 2007; Milovanov et al., 2008). Studies of such differences often place participants into musician and non-musician groups based on musical experience (e.g., Marie et al., 2011; Wong et al., 2007; Rammsayer & Altenmuller, 2006). Other studies measure musical aptitude instead of, or in addition to, musical experience (Cooper & Wang, 2012; Slevc & Mikaye, 2006; Schneider et al., 2005). Although experience and aptitude theoretically represent separable constructs (e.g., Gaede et al., 1978), the relationship between them has not yet been fully determined. We conducted an individual differences study of 160 participants. As part of this study on tone language learning, participants completed music aptitude tests, including subtests of the Wing Standardized Tests of Musical Intelligence (Wing, 1948) and the Advanced Measures of Musical Audiation (AMMA) (Gordon, 1989). Musical experience items were also collected, and were comprised of the Ollen Musical Sophistication Index (OMSI, from Ollen, 2006), items from Cuddy et al. (2005), and questions about instrumental experience. An exploratory PCA of music variables yielded separate factors for aptitude and experience. Additionally, experience measures, but not aptitude measures, predicted successful tone language learning. When placed in the context of the additional cognitive variables examined, measures of musical experience and aptitude (Wing) loaded on a factor of pitch ability. However, the AMMA was not a part of this factor. Significant correlations were found among experience and aptitude measures. Music aptitude test scores were predicted by a combination of general cognitive abilities (e.g., working memory, verbal memory) and select musical experience questions. This study suggests that the relationship between music aptitude and experience is complex and requires additional study.

[1-21] The impact of music and language experience on auditory inhibitory control

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Recently, Bialystok and DePape (2009) investigated visual and auditory inhibitory control (suppression of conflicting sensory information) among bilinguals and musicians. For auditory inhibitory control, they used an auditory version of the Stroop Task involving words and discrete pitches, and found that musicians outperformed both bilinguals and monolinguals.

The current research builds on their work with two critical changes. First, we propose a separation of the category of "bilingual" into tone language bilinguals and non-tone language bilinguals. Tone languages (e.g., Mandarin) typically rely on pitch level and contour to derive lexical meaning, which may impact a speaker's perception of tone in other contexts. Additionally, we implement another auditory Stroop task using contour (rising and falling tones) rather than discrete pitch to investigate a different dimension of auditory perception.

Participants are assigned to groups (monolingual non-musicians, tone language bilinguals, non-tone language bilinguals, and musicians) based on language and music experience as determined by a questionnaire. They then complete pitch and contour auditory tasks presented on E-Prime. In the pitch condition, participants hear the words "high" and "low," spoken in high or low pitches. Their goal is to determine as quickly as possible whether the pitch heard is high or low, regardless of the word meaning. In the contour condition, participants hear the words "rise" and "fall" in rising or falling contours. They indicate as quickly as possible if the contour is rising or falling, regardless of the word meaning. Reaction times are recorded and compared.

We hypothesize that tone language bilinguals and formally trained musicians will demonstrate enhanced inhibitory control in the context of conflicting linguistic and pitch or contour stimuli, and thus perform better than monolinguals and non-tone language bilinguals on the pitch and contour tasks. We discuss the implications for shared language and music processing and their potential cognitive benefits.

[1-22] Differences in the detection of pitch changes within a music and speech context

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Shared and distinct mechanisms for speech and music processing are often studied using stimuli that are acoustically different from each other or consist of unnatural speech sounds perceived as speech or non-speech after training. While these approaches demonstrate distinct responses to speech and music stimuli, because acoustic characteristics of these stimuli are not identical, it is difficult to tease apart the contribution of high-level and low-level processes. The current study used an auditory illusion demonstrated initially by Deutsch et al. (2011), in which a single recorded speech excerpt subjectively transforms to song after several repetitions. Using 24 speech-to-song sentence illusions (Tierney et al., 2012), participants without musical training rated each of 10 repetitions of a speech segment according to whether it sounded like speech or like song. Additionally, participants performed a pitch change detection task for each stimulus when it was interpreted as speech (before repetition) and song (after repetition). Pitch deviations did or did not conform to expected western musical intervals, allowing us to examine whether knowledge of western musical structures would interfere with or facilitate pitch detection in the context of hearing the stimulus as speech or as song.

Preliminary data suggest that the perceptual illusion is not unique to musically trained listeners. A comparison of d' scores for conforming and non-conforming pitch deviations during the initial (sounds like speech) and final (sounds like song) same-different tasks suggests increasing sensitivity to non-conforming pitch deviations and stable sensitivity for conforming deviations. These preliminary trends implicate the recruitment of music-specific knowledge during the perception of a spoken stimulus that is heard as song. The role of rhythmic regularity in the transformation from speech to song will also be discussed.

[1-23] Vowel duration and F0 stability in singing vs. speech

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For some people with speech and language disorders, singing is reportedly easier than speaking. Consequently, musical elements have formed the basis for some interventions for nonfluent aphasia, acquired apraxia of speech, and stuttering. It is unclear, though, why singing may be helpful. The aim of this study was to test the hypothesis that the F_0 of vowels is more stable in singing than in speech. A secondary hypothesis was that vowel duration is longer in singing than in speech.

We extracted and analyzed publically available sound files of 12 experienced singers producing a phrase from Deutsch's *Speech to Song Illusion*. Six of the participants sang the phrase, and 6 spoke it. Vowel durations were significantly longer in the sung compared to the spoken condition. F_0 stability (ΔF_0/time) showed a non-significant trend consistent with our hypothesis.

Wanting a larger sample size, we recorded 39 healthy adults speaking or singing the same target phrase. Six raters judged each sample as spoken or sung. Only samples with strong overall agreement were analyzed (17 spoken and 15 sung). Vowel durations were again significantly longer in the sung condition. F_0 stability did not differ between groups, but we noted a potential confound: mean overall F_0 was greater in the sung samples compared to the spoken ones. We corrected for this by expressing F_0 stability as (% change in F_0)/time and found a difference between groups, such that F_0 stability was significantly greater in singing than in speech.

Singing may be characterized in part by longer vowels with flatter F_0 contours. Particularly for people with motor planning deficits such as apraxia of speech, these elements could make production easier. Increased F_0 stability may result in steadier targets and fewer demands programming the laryngeal musculature. In addition, the longer vowel durations may accommodate slowed processing speed.

[1-24] The effect of language background on the perception of tonal groupings

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When listening to tone sequences, individuals tend to hear groupings of the tones, even in sequences comprised of physically identical sounds. When successive tones contrast in duration, listeners tend to form binary groupings with final prominence, eliciting a "weak-strong" (iambic) perceptual pattern. When successive tones contrast in intensity, listeners tend to form groupings with initial prominence, eliciting a "strong-weak" (trochaic) pattern. Previous studies investigating iambic/trochaic biases in perceived grouping of elements in tone sequences have suggested that these preferences may be influenced by language background. Iversen, Patel, & Ohgushi (2008) proposed that the iambic bias for sequences contrasting in duration may be related to the phrasal structure of English whereby short duration (weak) function words tend to precede long duration (strong) content words (e.g., 'a bus'). The current study aims to test this hypothesis. Experiment 1 tested native English speakers for their perception of grouping of simple rhythmic sequences consisting of alternating tones varying in duration. Participants were tested in two conditions (with and without noise masking the start of sequences) and were instructed to respond whether they heard a 'strong-weak' or 'weak-strong' rhythmic pattern for each sequence. Results show that noise masking is effective in eliminating effects of order. Results also show a significant iambic bias (as expected), but not for all duration contrasts. Experiment 2 (in progress) tests speakers of Bahasa Indonesian using the same paradigm. Of interest is that Indonesian phrasal structure contrasts with English, in that longer duration content words tend to precede shorter duration function words (e.g., 'palu itu' [hammer the]). If language background influences grouping biases in accordance with the phrasal structure, then despite use of duration and intensity in both languages as cues to stress patterns, speakers of the Indonesian language should show a trochaic rather than an iambic bias for tone sequences.

[1-25] Musical abilities and phonological awareness in Brazilian children: A correlational study

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The relationship between musical skills and phonological awareness has interested scholars from various fields, both for enabling research on music cognition in childhood, and by presenting alternatives for the study of music and language (Bolduc, 2009; Herrera, Defior & Lorenzo, 2007; David et al., 2007; Moyeda, Gómez & Flores, 2006; Gromko, 2005, Anvari et al., 2002; Peynircioglu et al., 2002; Lamb & Gregory, 1999; Barwick et al., 1989). Yet, few studies to date have been conducted with Brazilian children.

Following previous works (Anvari et al, 2002) the present investigation aimed to verify the existence of correlations between musical and phonological awareness skills in Brazilian Portuguese speakers. Forty preschoolers (aged 4-5) Southern Brazilian children took part in this study (Pacheco, 2009). Children underwent two individual testing sessions that measured musical abilities (perception and production rhythmic and melodic) and phonological awareness (identification and synthesis of rhymes, syllables, onset-rime, and phonemes). Results suggested that there was a significant correlation between composite scores of musical abilities and phonological awareness. Significant correlations were found between all variables, namely, musical perception, melodic production, rhythmic production and phonological awareness, except between phonological awareness and rhythmic production. Findings are discussed in light of existing studies. This study extends the research *corpus* by adding data on children from non-European or North-American contexts, and draws implications for future works.

[1-26] Vocal and musical expressions of emotion in Azadari (Shiite mourning rituals)

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The study of emotion is a current topic in both music and language cognition. For example Individuals' felt and perceived emotions in music listening and the vocal expressions recognition in speech and portrayals can be mentioned. Furthermore recitative (musical declamations of narratives and dialogues) is an important part of different religious rituals, such as in healing (Zaar), worshipping (Prayers), and commemoratory and mourning rituals (laments and shrines in Shi'a). Some sects of Shi'a annually hold commemoratory rituals (Azadari) for important martyred Shiite figures, in which a reciter expressively narrates the story of martyr's life and martyrdom, and the listeners, in response, lament and shed tears. Emotional storytelling is an important task and skill for the reciter in order to reconstruct and portray the emotional and moral content of martyrdom scene. The aim of this study is to explore and examine this specific recitation method from its nonverbal aspects of conveying emotions. This study aims to investigate 1) The reciter's encoding style of vocal expressions, 2) the listeners' (Both insiders and outsiders) decoding techniques of emotion recognition, 3) and finally to investigate the role of musical expression in recitation. The study consists of listening tasks and rating scales. The listening task consists of examples of real (verbal) Azadari and manipulated nonverbal version of excerpts. The results will be acquired according to the listeners' responses and differences in emotion recognition and considering verbal and nonverbal versions. Additionally the acoustic features of Azadari excerpts will be extracted in order to investigate the reciter's encoding means of vocal expression.

[1-27] Can we dissociate the musical emotional pathway from the vocal one?

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Why does music move us? Recently, certain brain areas (e.g., striatum, amygdala) have been associated with musical emotions processing. These same areas have also been associated with basic biological functions (sex, pain). How can we conceptualize the relations between music and these neurobiological substrates? One possibility is that music co-opts or invades emotional circuits that have evolved for biologically important vocalizations (e.g., laughs, screams). There is currently little experimental support for the existence of a common musical and vocal channel. By using fMRI while presenting very comparable (acoustically, ecologically) emotional musical and vocal stimuli, we aim to provide an in-depth comparison of the musical and vocal emotion channels and identify their common neurobiological substrates. Two batteries of stimuli depicting basic emotional expressions (happy, sad, scary, neutral) were used: the Montreal Affective Voices (non-linguistic vocal bursts; mean duration:1.3 sec) and the Musical Emotional Bursts (improvisations or imitations of an emotion on a violin or a clarinet; mean duration:1.6 sec). Twenty participants realized a one-back task while listening to the affective bursts presented in blocs of forty stimuli by timbre (violin, clarinet, voice), and repeated four times. Univariate analyses, performed using SPM, revealed an interaction (emotion x timbre) in the temporal lobes: vocal fear elicited stronger activation than their music counterparts and the opposite was found for happy stimuli. Activation patterns by vocal and musical emotions showed striking similarities. Ongoing analyses using MVPA will help determine if the musical emotional pathway can be dissociated from the vocal one.

[1-28] Beyond listening: Musical and semantic effects of favorite songs

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It has been suggested that music can elicit changes in emotion and arousal, and induce self-rumination. The current experiment aimed to elucidate the role of both musical and semantic factors in bringing about these changes in cognition. Fifty-eight participants were placed into one of three conditions. The first listened to one of their favorite songs, the second read the lyrics to one of their favorite songs, and the third listened to white noise as a control condition. Participant mood and arousal was measured using the Brief Mood Inventory Scale before and after the experimental stimuli. Measures for self-focus and meaning in life were collected after the experimental stimuli using a pronoun completion task and the Meaning in Life Questionnaire respectively. Results were statistically significant between groups for mood $F(2,55) = 17.16$, $p = .000$ and arousal $F(2,55) = 6.631$, $p = .003$. Post hoc testing revealed that reading favorite song lyrics and listening to favorite music showed similar ratings in mood and arousal. These findings suggest that the mood and arousal altering capabilities of familiar music extend beyond active listening, and can be utilized via semantic processing and memory recall.

[1-29] The musical chill in musicians and non-musicians: Investigating involuntary bodily sensations experienced while listening to classical instrumental music

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Various studies have explored the experience of chills—goose bumps, shivers down the spine—in response to music. Experiences of chills have been compared by gender, valence of experienced emotions, and musical harmonic structure and texture (Panksepp, 1995; Sloboda 1991). However, the relationship between music training, emotion, and the experience of a chill remains unexplored. Within the genre of classical instrumental music, we aimed to investigate 1) whether musicians and non-musicians differ in the frequency and intensity of chill experience, 2) whether the emotions felt at each chill moment are similar between the two groups, and finally 3) whether familiarity with the music affects the chill experience.

In the current study, participants listened to 19 pre-selected, short excerpts of classical instrumental music, and were asked to immediately report when they experienced a chill and their emotions at the exact chill moment. To assess emotions, we used the Geneva Emotional Music Scale (GEMS), a list of nine adjectives specific to rating music-induced emotions (Zentner et al, 2008). Participants repeated the process for the remainder of the excerpt. In addition, participants were asked to report their overall emotion at the end of the excerpt as well as level of familiarity with the music.

We have so far assessed 6 musicians and 6 non-musicians and found that musicians report experiencing significantly more chills than non-musicians. For the chills that were experienced by musicians and non-musicians, the time and the reported emotion for each chill experienced was similar for both groups. "Power" and "tension" were the most frequently reported emotions, often occurring together. Additional results will be presented at the conference, as more data is being collected, as well as a discussion on the implications of the results.

[1-30] Evolution coupled with music pleasure sex-selects for music emotions; surprisingly, this says something about language

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We show that given two simple assumptions about music, evolution would select males with enhanced music memory. Then, because emotions enhance memory, selection would occur for music evoked emotions. The selection for enhanced music memory occurs because of three factors: 1) Humans have a cognitive rule system for music (as in Meyer and Narmour) which executes during creating music and listening to music (it provides pleasure and anticipation during music listening). Additionally, that rule system acquires and integrates new rules (subconsciously) merely by listening to music. However, the cognitive processing for acquiring those new rules requires remembering the music and the executing rules–a demand on memory. Therefore, during music listening, an enhanced music memory would enable acquiring new music rules more quickly and reliably; 2) Cognitively possessing more and better music rules (acquired by listening) enables a person to create more pleasurable music (the critical assumption); 3) Female choice sex-selection occurs because of pleasure; therefore, by creating more pleasurable music, a reproductive advantage is gained by males who acquired more music rules because they are better at remembering the music; hence, evolution selects males with greater music memory. It then follows that since the emotions enhance memory, the emotional circuits would be targeted for music. Applying the neuroscience of emotional memory shows this mechanism completely characterizes emotions from music [why happy and sad music, why sad music is pleasurable, and the what and why of chills]. Because other traits would be similarly selected, the origin of music merely needed to be a simple rule system that causes pleasure; with that, music would develop to the current complex rule system. Lastly, because music emotions [nor those other sex-selected traits] appear without sex-dimorphism (a difference in the sexes), another powerful mechanism (which must exist) prevents sex-dimorphism. That mechanism illuminates a necessary interdependent relationship of music with language: without the other, neither could exist as they are.

[1-31] Interacting factors that influence the perceived happiness, excitement, and enjoyment of music

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The majority of previous studies on musical factors that influence emotional responses varied one factor and measured one response. The purpose of the current experiments was to investigate how musical factors interacted and to assess three responses, happiness, excitement, and enjoyment. In experiment one, two pieces of classical music were chosen. One, a Beethoven "Minuet," was originally in major mode and the other, Schumann's "First Loss" was originally in minor mode. Each piece was presented both in major and minor, and each of these was played at three different octave transpositions. Subjects rated the major mode as happier than the minor mode. Happiness was rated highest when the major piece was in the middle octave, slightly less in the higher octave, but much less in the lower octave. The pieces in minor mode were rated the same in the medium and higher octaves, but became even sadder in the lower octave. Major mode pieces were rated as most exciting in the medium octave. The minor pieces were less exciting than the major pieces, but most exciting in the lower octave. Pieces were enjoyed most in the medium octave and least in the lower octave. In experiment two each piece was also played loudly and softly. Varying the loudness had no effect on happiness, but had an effect on excitement, louder pieces were rated as more exciting and subjects found softer pieces more enjoyable.

In summary, music is more effective in eliciting happiness and excitement in the middle octaves. Most popular music, is written in this range. It is also extremely intriguing that varying loudness had such a dramatic effect on excitement, but not on enjoyment and happiness. Future research might investigate whether participants process loud sounds with a more primal mechanism related to fight or flight kinds of responses

[1-32] Music increases the perceived unity of video walkers

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Thompson (2009) suggests that one of the evolutionary functions of music is to promote group bonding. Harring and Edelman (2012) tried to separate out the effect of music on group bonding from that of mood and synchrony. The results were mixed. The current studies were designed to evaluate the role music enjoyment plays in group bonding. Our methodology was based on that of Miles, Nind, & Macrae (2009). We created two ten second videos of women walking. In one video they walked in synchrony and in the other asynchronously. Two experiments were run using the same videos but different music.

Based on a pretest, *Stereo Heart* by Gym Class Hereos was used in the experiment. Each participant saw one of the two videos (synchronous or asynchronous) with or without music. After viewing the clip, participants filled out an entitavity questionnaire (Postmes, Brooke, & Jetten, 2008) and a rapport scale (Puccinelli & Tickle-Degnen ,2004). Music ($F(1,56) = 4.11$, $p < .05$) and synchrony ($F(1,56) = 6.86$, $p < .01$) increased ratings of entitavity. Music ($F(1,56) = 12.69$, $p < .01$) and synchrony ($F(1,56) = 3.94$, $p < .05$) increased ratings of rapport. However, the music was rated lower on familiarity and liking in our experiment than in our pretest.

After a more extensive pretest, the song *Party Rock Anthem* was used in the second experiment. Although synchrony had a significant effect, music did not. However, correlations indicated that the more participants identified with the music the greater they rated the entitativity ($r(54) = .541$ $p <.01$), and the greater they rated the rapport ,$r(54) = .54$, $p <.01$. Thus participants' perception of the music seems to influence the degree to which music has an effect on social bonding. Future studies should use a wider range of music, varying both liking and familiarity.

Friday 9 August

Talk Abstracts

[2A-1.1] Musical and linguistic structural processing: The role of cognitive control

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The relationship between structural (or syntactic) processing in music and in language is not yet clear. Evidence that musical and linguistic structure recruit non-overlapping neural regions suggest these processes are largely distinct. In contrast, studies involving simultaneous presentation of music and language find interactive effects, suggesting shared processes. Thus musical and linguistic syntax may share some, but not all, underlying processes, raising the question of what exactly those shared (and distinct) processes might be.

Linguistic syntactic processing has been claimed to rely on , the process of detecting and resolving conflict that occurs when, e.g., syntactic expectations are violated. One possibility is that cognitive control also underlies musical syntactic processing. If so, less expected chords should impose greater demands on cognitive control, leading to a temporary reduction in the ability to exercise cognitive control in other tasks. We paired short chorales with the Stroop task, a prototypical cognitive control task where participants name the ink (font) colors of written words. Cognitive control demands are reflected in the Stroop effect–longer response times on conflict trials (e.g., "green" printed in red) compared to neutral trials (e.g., "xxxxx" printed in red).

Participants heard six-chord chorales and performed a Stroop task during the final chord, which was harmonically expected (the tonic chord) or harmonically unexpected (a chord belonging to another key). The Stroop effect was significantly larger when accompanied by a harmonically unexpected chord than when accompanied by an expected chord. Importantly, a control experiment using expected and unexpected timbres showed no such interaction, thus these interactive effects do not simply result from surprise or distraction. Instead, these data show that cognitive control processes are involved in the processing of musical structure, suggesting cognitive control is one specific process underlying shared syntactic processing in music and language.

[2A-1.2] Music experience predicts lexical tone learning

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Lexical tone languages employ voice pitch, in conjunction with segmental speech sounds, to determine word meaning. The ability to produce and perceive tones is difficult for many second language learners whose first language does not utilize tone (e.g., Lee, Vakoch, & Wurm, 1996; Wayland & Li, 2008). Previous work has shown that successful initial learning of lexical tone contrasts may rely on pitch processing abilities developed through prior musical experience (e.g., Alexander, Wong, & Bradlow, 2005; Wong & Perrachione, 2007; Cooper & Wang, 2012). However, additional work is needed to determine how musical experience and aptitude (e.g., accurate pitch perception) interact with various other cognitive factors known to play a role in foreign language learning. The current study addressed this question through an individual differences study of tone aptitude – that is, the ability to learn to use lexical tone in a foreign language context. Native English-speaking participants (n=160) completed a set of pre-tests and five training sessions involving word-learning with minimal tone quadruplets, similar to Wong & Perrachione, 2007. Participants ranged in musical experience from non-musicians to musicians. Predictors included 21 measures covering several constructs, including musical experience, musical aptitude, nonlinguistic pitch processing, working memory, general intelligence, implicit induction, and prior language experience. Regression analyses indicated that aspects of musical experience predicted success on the tone learning task. However, the pattern of results differed between performance on the last training task and performance on a

novel voice transfer task. Musical experience, as well as music aptitude, correlated with general cognitive measures, such as non-linguistic pitch processing and working memory, which also predicted learning success. Thus, the current study demonstrates that musical experience affects skills that are transferable to initial stages of lexical tone learning and involves skills that overlap with other cognitive functions important for word learning in tone languages.

[2A-1.3] The role of auditory feedback in speech and song

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Fluent production of sequential behaviors is, in part, reliant upon the coordination between perception and action. Here we focus on music and language (produced via speech and song), which differ with respect to temporal constraints, pitch precision, grammatical constraints, and the magnitude of individual differences in production ability. The specific focus of this research is whether a phenomenon revealed in research on music production, the "sequencing/timing dissociation" holds for the use of feedback in speech as well. The dissociation effect (cf. Pfordresher, 2003), comes from distinct effects of different altered auditory feedback (AAF) manipulations on the performance of music (Pfordresher 2003, 2006). Temporal asynchronies between auditory feedback and their associated actions affect production timing but do not disrupt accuracy of event sequencing. Conversely, manipulations that affect contents (pitch) disrupt sequencing but not timing. These effects suggest a hierarchical stratification of sequencing and timing in a shared representation that underlies the perception and production of sequences. The three experiments reported here examine whether these disruptive effects are found in the domain of speech production. In different experiments, participants produced wordless melodies, sequences of spoken nonsense syllables, sung melodies comprising nonsense syllables, and simple monosyllabic sentences. Across most tasks, the sequencing/timing dissociation held, apparently supporting the idea that a common representation underlies the coordination of perception and action across domains. However, there was a slight tendency for alterations of contents to disrupt timing for the production of sentences, and the overall magnitude of disruptive effects differed across tasks. Taken together, results suggest that the coordination of perception and action during sequence production is served by a common representation that nevertheless can be influenced by higher-order structural information that is present in language.

[2A-1.4] Shared syntactic processing mechanisms in music and language: A brain imaging study

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Music and language have been proposed to share basic syntactic integration resources. Using functional magnetic resonance imaging (fMRI) this study aimed to find out whether evidence for this proposal can be found using brain measures and if so where in the brain these shared resources reside. As opposed to previous brain imaging studies we went beyond an investigation of regional overlap in music and language processing. Instead, we used a design whereby language processing directly interacts with music processing, if both share neural circuitry. In a completely within-subjects 2 (language) × 3 (music) design, 19 non-musicians heard 240 sentences sung a cappella. Stimuli contained either easy language syntax (subject-extracted relative clause) or difficult syntax (object-extracted relative clause). At a critical sentence position singing was either in-key (thought to facilitate syntactic integration of tones), out-of-key (syntactically challenging), or unusually loud. The latter was used to control for attention capture effects and activated the right hemisphere's inferior frontal gyrus. The interaction between language syntax and music harmony, on the other hand, behaved differently and could be localised in the anterior part of the left hemisphere's inferior frontal gyrus: Broca's area pars triangularis and pars orbitalis. This brain area has previously been associated with the integration of elements across linguistic levels. Our findings provide direct evidence for the recruitment of the same high level syntactic integration resources in this brain area for two different cognitive domains. This suggests that music and language do not only share neural circuitry during low level input (audition) and output (motor control) stages. Instead, a common requirement of structured sequence comprehension - syntax - appears to rely on the same supramodal brain region.

[2A-2.1] Investigating the effects of beat salience on beat synchronization judgements during music listening

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Synchronized movement to an external beat is a near-universal human ability, yet the underlying perceptual and cognitive mechanisms are not well understood. We investigate the effects of beat salience—a categorical measure of the perceptual prominence of the beat—on the perception of synchronization while listening to music. As beat perception occurs implicitly, at a nearly automatic level (Ladinig et al., 2009), we use a reaction-time (RT) paradigm often employed to examine cognitive processes residing beneath conscious awareness.

Thirty participants were presented with musical excerpts superimposed with an isochronous (metronome-like) pulse sequence. They were asked to indicate as quickly as possible whether the sequence was synchronized with the music. Proportion correct and RTs were measured. Twenty-four 17-s excerpts of popular and electronic music were selected in a pre-study to represent low, medium, and high levels of beat salience. The pulse sequence was either synchronized or slightly desynchronized (75 ms early or late) with the phase of the music, and began either on or off the downbeat, resulting in a 3 (beat salience) x 3 (phase) x 2 (metric position) factorial design.

Results for proportion correct and RTs indicate significant main effects of beat salience and phase, and a significant beat salience x phase interaction. Participants responded most quickly in the high beat salience condition with synchronized phase. For proportion correct in the high beat salience condition, participants overwhelmingly indicated that the pulse sequence was synchronized, even in the early and late phase conditions. The large number of false alarms suggests that phase errors were masked by the prominence of the beat in these excerpts. We are currently exploring this finding under a wider range of phase offsets as part of a larger project on the effects of beat salience on perceptual and motor coordination processes implicated in sensorimotor synchronization.

[2A-2.2] Tactus in the B section

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In most experiments studying perceived tactus participants are rendered metrically naïve before the presentation of each stimulus. Most music, however, is multi-sectional, filled with formal and textural boundaries of many types. To what extent is a listener's choice of tactus in subsequent sections of music influenced by the preceding music?

A study was conducted to investigate how perceived tactus in a piece's second section (generically, the B section) was influenced by a preexisting tactus from the piece's A section. 35 musician participants tapped perceived tactus in response to 15 excerpts of diverse styles, hearing the target music of the B section in either a "primed" (A-B) or "unprimed" (B-only) condition. Each participant heard each excerpt under only one condition.

The junctures between A and B sections in these excerpts were of two types. In Type 1 (seven excerpts), the metric structures of the A and B sections were similar in terms of meter type and performance tempo, with at most two metrical layers added or subtracted across the sectional boundary. Participants' perceived tactus in the B section of these excerpts was significantly different between conditions for all seven excerpts.

In Type 2 boundaries (eight excerpts), the A and B sections had differing meters and/or performance tempi, with at most two metrical layers in common. Responses to only two of these eight excerpts showed significant differences between conditions, suggesting that participants generally experienced these musical boundaries as tactus reset buttons, processing meter in the B section similarly whether or not it was preceded by A.

This study suggests that listeners can be primed to hear a tactus in a subsequent section of music that they would not otherwise choose, but that the connections between adjacent sections needs to be close or listeners will process a B section much like an A section. Thus, even though tactus choice is always constrained by tempo, metric structure, and individual preference, composers can manipulate and direct perceived tactus across musical boundaries via meter and tempo relationships.

[2A-2.3] Microtiming in Ngòn: Categorical production and perception of non-isochronous rhythms

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This presentation documents the precise timings used in several performances of "Ngòn Fariman," an ensemble drumming piece from Mali whose core rhythm is characterized by a pattern of Long-Short1-Short2 beat subdivisions. Timing data is analyzed within and across several performances to provide evidence of discrete categories of beat subdivision (Long vs. Short) as well as evidence of expressive variations within each category (Short1 vs. Short2. The effects of the large-scale structural acceleration, characteristic of Ngòn, and the presence of performance-specific microtiming patterns, are also assessed.

A one-way ANOVA analyses found statistically significant differences among all elements (Long, Short1 and Short2) of the beat subdivision, including small but significant differences between Short1 and Short2 in all performances. Post hoc tests found statistically significant differences among all six performances for the Long and Short2 elements of the beat subdivision, and mixed results for the Short1 element; this tendency was also evident in a non-significant result for the linear term analysis of Short1 in the initial ANOVA. Paired t-tests showed small but significant differences in the Short element ratios between the beginnings (slow) and endings (fast) of each performance; a general tendency toward convergence is evident (e.g., from 40:31:29 to 40:30:30).

Timing data support the ascription of two distinct subdivision categories in Ngòn that are not based on simple (2:1) integer ratios. The data also show distinct and stable within-category variations indicative of intra- and inter-performance expressive nuances or "swing feels." The data prompt revised theories of metric well-formedness to accommodate non-isochronous subdivisions while maintaining maximal evenness on higher levels of metrical structure.

[2A-2.4] Patterns of neural activation and suppression that underlie musical meter

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Musical meter is an abstracted hierarchy of temporal regularities that helps listeners organize and predict information in rhythmic sounds. In the brain, meter is proposed to arise from the intrinsic behavior of non-linear neural oscillators driven by perceived rhythms (pulse resonance theory), but dynamic neural activity predicted by this framework is not fully characterized.

Thus, we conducted a study whereby sixteen participants listened to an equally-spaced (600 ms IOI) sequence of 22 identical sounds and probed for one deviant sound that was reversed in temporal waveform. Meanwhile, participants also imposed march (binary) or waltz (ternary) meter over the rhythm. After, participants reported the metric position (strong or weak beat) on which the deviant stimulus occurred. Each participant completed 120 trials: five blocks of binary trials and five of ternary; every block contained twelve sequences. The electroencephalogram was recorded for all subjects.

We used task partial least squares analysis to identify oscillatory activity relating to strong and weak beat impositions for beats preceding the deviant stimulus, and found two significant latent variables (LVs): The first LV ($p < .001$, accounting for 68.5% of the covariance) contrasted brain activity following strong metric positions in ternary meter. Follow-up bootstrap tests indicate evoked spectral power in the alpha band (9-14 Hz) increased ~200 ms before weak beats and co-modulated with decreases in delta (2-4 Hz) power. A second significant LV contrasted the terminal weak beat in ternary meter from other metric positions ($p = .039$, 48.9% of the covariance), indicating beta band (16-24 Hz) power increases ~150 ms before strong beats. Together, we interpret these novel findings as cortical synchronization before strong beats and cortical suppression before weak beats. As all sounds were identical, the findings can be attributable to endogenous meter maintenance and offer further support for pulse resonance theory.

[2A-2.5] Is subjective rhythmization a form of beat perception?

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The perception of a regular beat is fundamental to our understanding and enjoyment of music. Humans have the remarkable ability to perceive a regular beat in music even if it is not present in the physical sound. A prime example of this is subjective rhythmization, a process by which we hear a regular beat in an isochronous sequence of tones, usually on every other tone (Potter et al., 2009). The processes underlying subjective rhythmization are ill understood. One explanation is that subjective rhythmization is the result of fluctuations in attentional energy, as has been suggested for beat perception in general (Dynamic Attending Theory, see Large & Jones, 1999).

We examine subjective rhythmization using an isochronous sequence in which every fourth beat is marked to ensure that participants hear the beat with the same phase. We compare the speeded response to rare sound increments and decrements, both in subjectively accented and non-accented positions. These deviations from the regular pattern occurred with different magnitudes, ranging from 4 to 9 dB. Dynamic Attending Theory predicts a processing advantage for all deviations in subjectively accented positions, as attention is heightened there.

Our results show this processing advantage for large deviations, however, for smaller deviations a different response pattern emerges. Small sound increments are processed faster in subjectively unaccented than accented positions, probably due to their larger perceived salience in unaccented positions. While this makes intuitive sense, it is not in line with the predictions of Dynamic Attending Theory. We thus propose that subjective rhythmization consists of multiple processes working together in shaping our perception. We show preliminary EEG results supporting these behavioral results and our conclusion. This raises the question whether beat perception and subjective rhythmization can always be explained in terms of fluctuations in attention and whether possibly other processes must be considered.

[2A-3.1] Atypical processing of pitch: A behavioral and electrophysiological exploration of the effects of autism traits and musical training

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Autism has been shown to be associated with increased pitch discrimination (Heaton, 2003). However, though it has been proposed that autism traits extend across the general population (Piven et al., 1997), whether this is the case for concurrent perceptual enhancements has been little explored. Using the Autism Quotient (Baron-Cohen et al., 2001), this study investigated the relationship between autism traits and pitch discrimination in the neuro-typical population. Musical training was also investigated, since enhancements in pitch discrimination are also evident in musicians.

A forced-choice paradigm was implemented, with behavioral and EEG data recorded during presentation of pairs of verbal, and pitch analogue, stimuli. Within each pair, stimuli were either presented at the same pitch, or with the contour of the second stimulus transposed upwards by 2 or 6 semitones. Fine-grained discrimination ability was of primary interest, therefore all analysis focused on the 2-semitone condition. Behaviorally, discrimination accuracy significantly correlated with musical training (r=.50), itself a positive correlate of the attention to detail autism subscale (r=.50). Furthermore, when discrimination accuracy for verbal stimuli was compared to that of pitch analogue stimuli, a regression analysis found the difference to decrease with musical training, yet increase with autistic attention-switching impairment (adj. r2=.38). Electrophysiologically, regression analyses revealed significant effects of communication ability with respect to N1 latency (adj. r2=.30), and social skill with respect to P3 amplitude (adj. r2=.22).

That N1 latency and P3 amplitude distinguish between high and low AQ traits has not previously been shown. Furthermore, the striking finding of a different set of autism characteristics being relevant in the behavioral component (attention-switching and attention to detail), compared to the electrophysiological component (communication and social skill), of this study has significant implications regarding the conceptualisation of autism, implying a division between the cognitive style of the disorder and its symptomatology.

[2A-3.2] Using music to explore sensory processing in autism

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Autism spectrum disorders (ASD) are characterized by impairments in social skills and communication. Individuals with ASD have difficulty with audio-visual integration, which may contribute to some of the core symptoms of the disorder. However, the full extent of their sensory integration abilities is not yet well understood. For example, studies using high-level, language-based tasks have found that individuals with ASD do not use lip movements or manual gestures efficiently to improve speech perception. Conversely, research investigating low-level integration of auditory-beeps with visual-flashes suggests intact integration of simple, non-social stimuli. However, this work involves artificial synthesized sounds and stationary visual images, which are not necessarily indicative of real-world perceiving. Furthermore, it is unclear whether documented high-level sensory integration dysfunction is related to the use of language-based research tasks. Here, we used musical stimuli to help resolve these issues by presenting participants with videos previously used to explore a audio-visual illusion used by musicians to manipulate the perceived duration of marimba notes (Schutz & Lipscomb, 2007).

These videos serve as useful stimuli to assess natural audio-visual integration as they use biological motion and ecologically common sounds (i.e., impact sounds, rather than synthesized tone beeps). Participants were 24 individuals with high-functioning ASD and 24 typically developing (TD) controls, matched on age, gender, and IQ between the ages of 13 and 18. They watched videos of single notes performed with either short or long gestures, and were asked to judge the duration of the heard note independent of the seen gesture. Surprisingly, individuals with ASD appear to integrate no differently than the TD controls, suggesting a lack of integration deficit in this real world perception task. These findings have potential implications for understanding core features of sensory processing in ASD and for designing related treatment interventions.

[2A-3.3] Music and linguistic benefits of music training in deaf children with cochlear implants

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Increasingly, Deaf children are being implanted with auditory prostheses known as cochlear implants (CI) that are able to restore some, but not all auditory cues. Children using CIs exhibit impairments in pitch processing, which is necessary for understanding the emotional intention in spoken language. Given the positive correlation between the accuracy of auditory discrimination of emotion and quality of life, the social implications of these limitations are clear. At least one investigation has demonstrated that music instruction may support the perceptual development of emotional prosody (Thompson et al., (2004)). However, It is currently unknown as to whether deaf children who use CIs experience similar benefits. Gfeller, et al (2000) demonstrated that a music-training program could improve the musical perception of individuals using CIs. The current study extends this line of inquiry to encompass additional dependent measures. It was hypothesized that children would transfer their improved musical processing to other domains including perception and production of emotional prosody. Participants received six months of vocal and keyboard lessons at The Centre for Music Education and Cognition (C-MEC). A control group received visual art lessons over the same period. Participants were tested at three points in the study: before, during, and after lessons. The students were assessed on their music perception abilities, and the development of their abilities to both perceive and produce emotional intention in speech. Preliminary findings indicate that gains in auditory processing were greater for music lessons than for visual art lessons.

[2A-3.4] Development of Functional Adaptive Tests for the Assessment of Music Perception (FAT-AMP) in hearing impaired listeners

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The Functional Adaptive Test for the Assessment of Music Perception (FAT-AMP) is a new test battery that has been designed to investigate functional hearing in music in hearing impaired listeners. By functional hearing we are referring to hearing that supports the perception and production of music. In each test of the battery listeners are asked to make judgments concerning mid-level dimensions of music (e.g., meter, timbre, harmony and melody), while manipulating low-level dimensions (e.g., level or pitch) that give rise to the mid-level dimensions. Discrimination thresholds for low-level dimensions are then determined in an adaptive procedure using a 2AFC method. Test stimuli are synthesized and either unprocessed or processed by different hearing aid signal processing algorithms before being played back to listeners via loudspeaker. The battery will eventually be used to evaluate different hearing aid algorithms with regard to their benefit for functional hearing in music.

A group of six normal hearing control participants (6.3 dB HL) and five hearing impaired participants (34 dB HL) each performed the harmony subtest with unprocessed test stimuli twice at 40 dB sensation level.

Difference thresholds for each underlying variable were determined by averaging the values of the last four reversals. These thresholds were subjected to a mixed analysis of variance (ANOVA) with learning as the within-subjects variable (test; retest) and hearing status (normal; hearing impaired) as the between-subjects variable. Preliminary findings indicate that normal hearing participants had lower thresholds than hearing impaired participants, $F(1,9) = 6.94$ and 47.0, $p<0.05$ and that the effect of learning and its interaction with hearing status are not significant.

[2A-4.1] Caution: Octave ahead! A perceptual account of the direct octaves rule

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What goal is served by following the traditional Western voice-leading prohibition against Direct Octaves (a.k.a. Hidden Octaves or Exposed Octaves)? There are many guidelines and heuristics put forth in music theory textbooks, some of which seem unclear in their goal or purpose. Over the past two decades, research has shown that many voice-leading rules can be understood as consistent with perceptual principles that facilitate unconscious auditory organization of multipart textures (e.g., Huron, 2001). The current investigation follows in this tradition by testing possible perceptual or cognitive interpretations of traditional musical practices.

In this study, a series of experiments are conducted in order to determine the perceptual effects of stepwise approach to an octave. In the first part of this study, musically trained listeners were exposed to a series of isolated sonorities (both familiar and unfamiliar) and asked how many distinct pitches were present. Based on previous research we expect that listeners will underestimate the number of pitches present in chords that contain octaves due to tonal fusion, where the constituent tones combine to form a single auditory image (Stumpf, 1890; van Noorden, 1971; Rasch, 1978; Bregman, 1990). In the remaining experiments, octave-bearing sonorities were primed by step or by leap, and listeners were again asked to make numerosity judgments. We anticipate that the step-wise priming of the octave will help to overcome tonal fusion and lead to more accurate numerosity judgments. Experiments are ongoing and we expect to have results well in advance of the conference date.

[2A-4.2] Voice-leading proximity vs. harmonic diversity in explanations of chromatic harmony – A preliminary model tested on a Chopin's corpus

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Chromatic music of the nineteenth century is arguable the most successful of all styles of classical music. Considering its success it is ironic that our scientific understanding of the *cognition of chromatic harmony* is even more incomplete than the one of diatonic music. The article presents preliminary results of a larger project aiming at developing cognitive model of chromatic harmony inspired by neo-Riemannian music theory.

Existing theories applicable to chromatic music usually stress one of the following two principles. *Harmonic diversity* (HD) expressed through higher values of "tonal tension" is emphasized for instance in Lerdahl's (2001, 2007) model of tonal pitch space. In contrast, contemporary music theorists such as Cohn (2012) or Tymoczko (2011) evoke a different principle, *voice-leading proximity* (VLP), in their models. Which of these two principles reflects the properties of the chromatic music more accurately? To what extent do they overlap?

The theoretical part proposes computational methods for measuring HD and VLP. The empirical part reports on corpus analysis testing hypotheses about relevance of the two principles. The corpus consisted of all Chopin's mazurkas (51 pieces). Based on objective criteria, chromatic passages in the pieces were identified and manual chord analysis was conducted. The data on chord succession were the basis for calculation of characteristics related to HD and VLP.

While both principles are demonstrated by high values of the respective numerical variables in the chromatic passages, VLP is a slightly more sensitive index of chromaticism in our Chopin's corpus. However, in the discussion we argue that this does not mean that the principle of HD can be simply dismissed. While Chopin's chromaticism is characterized by high values of VLP and only moderate values of HD other chromatic repertoires might show different ratios. The two principles are related but neither of them can overrule the other one.

[2A-4.3] Voice-leading distribution and judgments of distance between tetrachords

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An intuitive way to measure distance between chords is to calculate the smoothest voice-leading between them, and then sum the absolute (non-directed) semitonal displacements of each voice. Known informally as "taxicab distance," this metric has gained currency in recent music-theoretic scholarship. However, empirical evidence (Callender, 2006) suggests that, when taken alone, it fails as a comprehensive model for how we perceive distance between chords: many variables in addition to sum semitonal displacement likely contribute to an overall perception of distance. The aim of this study was to control for relevant variables that previous studies have touched on only peripherally, including voice-leading distribution and set-class consonance, and to investigate whether these variables play a significant role in our intuitions of distance between pairs of tetrachordal pitch-class sets. In an experiment, participants listened to pairs of tetrachords and offered judgments of perceived musical distance for each pair. Three related hypotheses were tested: 1.) Given a constant taxicab distance, perceived distance between two tetrachordal pitch-class sets will be a function of how evenly this distance is distributed among the individual voices. 2.) Perceived distance will be less for common practice than for non-common practice tetrachord pairs. A third hypothesis confronts an issue of semantics: are chord relationships really perceived in terms of relative "distance/closeness," or rather in terms of relative "(dis)similarity"? We asked half of our participants to indicate their judgments of similarity, and the other half to indicate their judgments of closeness, with the conjecture that 3.) judgments from the former group will be significantly different than judgments from the latter group. The results correspond with those of previous studies (Callender 2006; Kuusi 2007), and offer new insights that may inform future research on similarity in music cognition.

[2A-4.4] Re-orchestrations of orchestral gestures: Theoretical implications and emotional impact

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Recent empirical studies indicate that timbral changes induce strong emotional responses in listeners. Large-scale changes in orchestration have not been theorized in music research to the extent other musical parameters have. Further research is necessary to identify generalized principles and a clear taxonomy of orchestral techniques and to develop a conceptual framework for their function and perceptual effect. In a previous study, we proposed a 2x2 model of orchestral gestures that categorizes them according to whether the changes are gradual or sudden, and whether they are additive or reductive. Participants listened to excerpts that fit within one of the four categories and continuously rated the intensity of their emotional responses. These data were used to isolate response patterns and investigate the connection to texture, dynamics, tempo, and spectral properties of the signal. In order to understand further the role of timbral changes within the context of these excerpts, we created re-orchestrations (with the assistance of composers John Rea, Félix Frédéric Baril and Denys Bouliane) to test the role of altering spectral centroid globally (brightened or darkened) and two hybrids created from recombinations (bright to dark, dark to bright). Realistic renditions of these re-orchestrations were created with the Digital Orchestra SIMulator (DOSIM), an orchestral rendering environment (developed by Bouliane and Baril), which allows for comparisons across versions by keeping performance timings and variations in dynamics constant. This study investigates the interaction of musical parameters and the timbral components of these re-orchestrations and discusses the music-theoretical implications of these alternate versions. We also outline the results of an experiment involving both psychophysiological (biosensors) and behavioral (arousal and valence) measures. By comparing these objective and subjective responses to the DOSIM renderings (originals and re-compositions), we will also assess the perceptual salience of the re-orchestration changes and the effect of timbre on the listening experience.

[2A-4.5] Effects of increased understanding of musical structure in aesthetic appreciation and judgment of classical music

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The power of music analysis to transform the ways in which listeners engage with musical works is a widely shared belief in the field of music theory, an assumption behind which lies the theorist's conviction that the apprehension of the musical structure contributes favorably to listening, facilitating the intellectual, emotional, and aesthetic interaction with the musical work. In a word, that analysis makes us hear pieces better (Lewin, 1969). However, not only is there no empirical evidence of the correlation between understanding and appreciation of music, but previous research (Margulis, 2010) has actually suggested that providing information about music can inhibit rather than increase the pleasure of listening.

The purpose of this study was to investigate the influence of analysis in the enjoyment of the listening experience and the perceived aesthetic value of pieces of classical music. Our participants watched one of three versions of a PowerPoint presentation containing written information and short excerpts of Chopin's *Ballade No.4 in F minor*. In the first condition, the presentation provided general statements about Chopin's style unrelated to the piece, while for the second and third conditions each slide included analytical information making reference to a particular excerpt. The second condition focused on formal, harmonic, and motivic aspects, whereas the third one presented a metaphorical interpretation based on Michael Klein's narrative analysis of the piece (2004).

After watching the presentation participants listened to the whole *Ballade* and then assessed their enjoyment of the piece and rated it in terms of four variables (beautiful, good, interesting, and moving). Mean ratings did not vary significantly across conditions; however, we found an unexpected significant effect in the correlations between the different variables. Whereas in the first condition some of the correlations were negative, in conditions two and three all correlations were positive and showed stronger significance.

[2B-1.1] Music as a kinesthetic pedagogical tool to teach mathematics in early elementary years

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Research suggests that musical activities help expand the capacity of the working memory, improve the ability to think, and develop good eye-hand coordination. Children who are exposed to musical learning environments tend to accumulate a larger repertoire of vocabulary, are generally better readers, and exhibit both enhanced cognitive and sensory abilities that give them a distinct advantage for processing speech in challenging listening environments. Such evidence in support of music stipulates the application of tools and techniques, which help facilitate meaningful musical experiences for elementary-aged children.

This study advocates for the use of music within the classroom environment as a pedagogical tool to teach other disciplines such as mathematics. Taking the multiplication table as an example, this paper will propose a newly designed kinesthetic pedagogical method for elementary school students to learn multiplication facts as they engage in fun musical activities such as singing, playing simple instruments, and craft making. Through the use of rhymes and music, this method aims to provide a more enjoyable and memorable experience through which children learn their multiplication facts. Furthermore, by using different meter, modes and tempo for each multiplication table, it aims to heighten children's emotions and play on their imagination. Musical scores, rhymes and a short documentary film from experimenting this method in an actual classroom will be presented.

[2B-1.2] Singing and cultural understanding

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This paper reports on one of the Advance Interdisciplinary Research in Singing (AIRS) projects, funded by the Social Sciences and Humanities Research Council of Canada (SSHRCC). The purpose of the study was to investigate whether singing songs from foreign cultures can lead to increase in understanding of those cultures. Between February and October 2012, 439 children from four countries, namely, Brazil, Canada, China and Kenya, participated in the research project. Over the span of 12 weeks, they learned six traditional songs from each country, a total of 24 songs, together with background information about the songs and cultures. Teaching materials including the songbook and PowerPoint slides in three languages (Chinese, English and Portuguese), and demonstration videos were produced to support and facilitate the teaching of these songs. Two schools in each country and two classes of children from each, ages 10 and 11, participated. One class learned both the cultural information and songs while the other class only learned the cultural information. Children responded to a questionnaire before and after the study to assess their attitude towards the people from the four countries. A questionnaire on the opinion on the songs of each country was also administered after the unit on each country. Interviews were conducted with both teachers and children at the end of the research. Teachers wrote a report on their observations on the lessons and the children's responses. Some lessons were observed and video-recorded by researchers. Children were also interviewed. Currently, the team is working on data analyses. Preliminary results of the study will be presented in the conference. Implications on the selection and use of multicultural songs in the classroom will be discussed.

[2B-1.3] Predicting who takes music lessons: The role of demographic, cognitive, and personality variables

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Children with music training tend to perform better than their untrained peers on a number of cognitive tasks, including tests of general intelligence. Although these results are typically interpreted as evidence that music lessons cause improvements in cognitive abilities, a simpler explanation is that high-functioning children are more likely than others to take music lessons. We asked whether individual differences in demographic, cognitive, and personality variables predict duration of music training in a large group of 7- to 9-year-old children who varied widely in duration of music lessons (from none to several years). Simple correlations revealed that duration of music training tended to increase in tandem with the child's age, family income, parents' education, duration of non-musical extracurricular activities, IQ, the parent's openness-to-experience, and the child's openness-to-experience and agreeableness, but to decrease with the child's neuroticism. When these predictor variables were considered simultaneously using multiple regression, personality variables predicted duration of music training when demographic and cognitive variables were held constant. Specifically, partial correlations revealed that the child's age and the parent's openness-to-experience contributed unique variance while controlling for other variables. Our results confirm that pre-existing differences determine which children pursue music lessons and for how long. In particular, it appears that young children whose *parents* are high in openness-to-experience – with parents who appreciate the arts and are interested in learning new things–are those who tend to become musically educated. Our results also suggest that studies examining associations between music training and cognitive skills need to consider contributions of personality variables.

[2B-1.4] The effect of music and error management training on a learning task

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Error management training (EMT) frames errors as beneficial for enhancing performance. EMT states explicitly that the complexity of tasks requires that errors need to be embraced. Errors provide feedback which indicates where one's mental model is not adequately developed, and thereby encourages its correction. EMT provides trainees with instructions in the form of heuristics that reframe an error as a beneficial rather than a negative occurrence, and emphasize that errors are a learning device. There are two main reasons for the effectiveness of error management training: First, errors provide feedback as to where knowledge and / or skills are in need of improvement. Second, error management training induces emotion control during training, and reduces potential frustration when errors are made. Music has been previously shown to affect emotion and mood, and to influence information processing and learning. The first aim of the present study was to examine whether the use of both EMT (with/without) and music (positive/ negative/ none) interventions would create an additive (better performance with positive music and error management combined), disjunctive (lower performance when the two interventions are combined) or an interaction effect. The second aim was to examine whether personality traits may moderate these effects. Participants completed two tasks with either positive/negative/ no background music, with or without information regarding common mistakes and tips aimed at facilitating solutions. Both objective performance and subjective evaluations of improvement were measured. In addition, participants completed the short version of Eysenck's (Eysenck, Eysenck & Barrett, 1985) EPQR-S and Snyder's (Snyder et al., 1991) dispositional hope scale. Data collection is in process. However, preliminary results show greater rates of success and a perception of tasks as easier with positive background music.

[2B-2.1] Differential short term memorization for vocal and instrumental rhythms

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Neurophysiological and imaging studies have shown that the human brain processes speech and non-speech sounds differently (e.g. Belin et al., 2000; Levy et al., 2003), and that vocal and instrumental melodic contours have differential effects on speech processing (Poss et al., 2008; Poss, 2012). A recent imaging study (Hung, 2011) found significant differences in processing of vocal and instrumental rhythms in early auditory pathways. The current study extends this research and asks whether differences between vocal and instrumental rhythms also exist in short term memorization.

In experiment one, 15 musicians and 10 non-musicians listened to a stimulus containing both vocal and clapstick rhythm patterns. After a shorter (.5 s) or longer (12.5 s) time interval the stimulus was repeated with or without alteration, and participants made same-different judgments on either the vocal or the instrumental rhythm of each pair. Analysis of accuracy and reaction time show: musicians are more accurate than non-musicians on clapstick but not voice rhythm judgments; musicians are faster than non-musicians on clapstick rhythms; there are multiple significant interactions between variables that show differences between voice and clapstick judgments. The participants were less accurate in judging vocal rhythms than clapstick rhythms, but vocal rhythms were also less prone to influence by other factors.

Experiment two tested the possible involvement of the phonological loop in vocal and instrumental rhythm memorization. 14 musicians and 12 non-musicians completed a control run (same as experiment 1), a run with a concurrent sub-vocalization task and a run with a simultaneous finger-tapping task. Results show both concurrent distractor tasks lead to the same reduction in accuracy, and that musical training and "same/different" judgments affect memory for voice and clapstick rhythms differently. These findings contribute to our understanding of memory for rhythm and the probability of different phylogenetic origins of vocal and instrumental music.

[2B-2.2] Music information retrieval from neurological signals: Towards neural population codes for music

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Much of music neuroscience research has focused on finding functionally specific brain regions, often employing highly controlled stimuli. Recent results in computational neuroscience suggest that auditory information is represented in distributed, overlapping patterns in the brain and that natural sounds may be optimal for studying the functional architecture of higher order auditory areas. With this in mind, the goal of the present work was to decode musical information from brain activity collected during naturalistic music listening. We used multivariate pattern analysis and music information retrieval (MIR) techniques to evaluate the extent to which various musical features could be predicted from brain activity. A simple linear classifier successfully predicted musical style from Heschl's gyrus (HG) but failed in superior temporal sulcus (STS). In contrast, the highest accuracy was achieved using a more sophisticated, nonlinear support vector machines classifier in STS. We posit that these differences reflect the information dynamics underlying musical style perception: STS calculates musical style and HG is modulated to reflect this categorization such that it can be linearly decoded. In a second experiment, we found that several spectro-temporal audio features could be accurately predicted from continuous, single-trial electrical brain activity using a linear regression model. Since there were no repetitions of the stimuli, these results cannot be explained by overfitting and must represent a general mapping between musical audio and electrical brain activity. Our experiments show that high-level musical labels can be decoded from hemodynamic brain activity while lower-level spectro-temporal features can be decoded from electrical brain activity. Ultimately we would like to construct a joint model that can take advantage of the different information present in various neurophysiological signals. We suggest that an interdisciplinary effort between auditory neuroscience, MIR, and music theory will lead to a better understanding of the neural mechanisms underlying music perception and

cognition.

[2B-2.3] Investigating the origin of the high voice superiority effect in music

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Music often requires auditory processing of more than one voice or stream at the same time. For instance, in polyphonic music each voice can be heard as a melody in its own right. To accomplish this, the auditory system must parse the incoming complex sound wave into parts that represent each individual voice. In previous work, we used event-related brain potentials (ERPs), to show that separate memory traces are formed for each of two simultaneous voices automatically and preattentively in auditory cortex. Furthermore, we found a larger mismatch negativity (MMN) response to deviant pitches in the higher than in the lower voice indicating better encoding of the higher voice. This was true in both infants and adults. Interestingly, the number of years of experience playing a bass-range instrument reduced but did not reverse the high voice superiority, indicating that although it can be modified with expertise, the effect persists even with extensive musical training. In the current work, we used a model of the peripheral auditory system to investigate the neural representations of simultaneously sounding musical voices at the level of the auditory nerve (AN). Model AN response properties demonstrate better pitch encoding (i.e., higher predicted salience) of the higher of two tones across a wide range of interval spacings and registers. The effect is greater in lower than higher pitch registers, with maximal high-voice salience occurring for intervals of around two octaves. The greater predicted salience for the high voice was found to arise from non-linear interactions in the inner-ear model between the harmonics of two simultaneous tones. Together the ERP and modeling work suggests an innate peripheral origin for the high voice superiority effect in polyphonic music. We infer that composers' choice of register and intervallic spacing might reflect physiological properties of peripheral sound processing.

[2B-2.4] Consolidation of procedural memories during skill acquisition and post-training sleep

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Our research group studies the nature of memory formation, in particular the process of memory consolidation, in the context of music performance skills (Allen, in press; Simmons & Duke, 2006; Simmons, 2012). We have observed that taking a break early in the initial practice of a new skill boosts performance such that by the end of training, learners given an early rest break outperform those who do not rest and those who rest late in practice, and they show greater consolidation-based skill enhancement following sleep (Cash, 2009; Duke, Allen, Cash, & Simmons, 2009). The purpose of the current study is to further examine this phenomenon by comparing rest intervals (time away from the target task) filled with various competing tasks: a declarative memory task, a second music task, and extemporaneous conversation with the proctor. Our goal is to determine whether the preliminary consolidation of the target task during the rest interval requires only time away from the target task or time away from any demanding cognitive activity.

Participants (N = 60) will learn a 13-note melody on a digital keyboard during individualized evening sessions, returning the following morning for individual test sessions. Training will comprise 12 30-sec practice blocks alternating with 30-sec rest intervals. Fifteen participants will take a 5-min break from the target task following the third practice block, during which they will engage in an informal conversation with the proctor. Another 15 participants, during the 5-min break, will practice a different 13-note melody. Another 15 participants, during the 5-min break, will attempt to memorize a set of 40 word pairs. The remaining 15 participants will not take an extended break from the target task. Participants will return the following morning, performing the target melody in three 30-sec test blocks alternating with 30-sec rest intervals. Data collection is underway.

[2B-3.1] Amplitude envelope: An important (but under appreciated) property affecting auditory perception

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A sound's amplitude envelope provides important information about the event leading to its production. For impact sounds (which are pervasive in musical as well as non-musical contexts) this property offers insight into the materials and force involved, in part through the envelope's offset/decay. Curiously, this cue is absent in sounds synthesized with the frequently employed "flat" envelopes (i.e., those using a trapezoidal shape), whose unnatural and abrupt offsets lack meaningful information. Recent work in our lab documents categorical shifts in sensory integration (Schutz, 2009), the recruitment of different strategies for duration estimation (Vallet, et al., under review), and improved associative memory performance (Schutz et al., under review) when using flat vs. percussive tones.

Intrigued by these differences we began reviewing the sounds used in auditory experiments, building on Tirovolas & Levitin's survey (2011) of empirical research published in the journal *Music Perception*. Surprisingly, 35% of the experiments we reviewed (n=222) failed to specify their tone's amplitude envelopes (Schutz & Vaisberg, in press). Ongoing surveys of other leading journals are revealing even higher proportions of unspecified envelope structures. This lack of specification does not reflect general neglect of detail, as other properties such as the exact model of headphones used and/or the precise model of synthesizer employed are generally specified in high proportions. This suggests that envelope's full significance has yet to be recognized, and that it represents a compelling area for fruitful future research. Consequently we are now sharing the software we developed to generate precisely specified tones with natural and abrupt offsets of any duration/frequency, which can be freely downloaded from www.maplelab.net/software. Together, we hope these findings and tools will inspire future explorations of amplitude envelope—an issue important not only for research focused on music cognition, but work exploring auditory perception in general.

[2B-3.2] 'Looming tunes': Continuous loudness response to acoustic intensity dynamics in melodies

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Research on auditory looming has shown that perceived loudness change is greater in response to tonal stimuli that continuously increase in acoustic intensity (up-ramp) relative to continuous decreases (down-ramp) of the same magnitude. However, a series of more psychoacoustic studies investigating decruitment and sensory adaptation report greater perceived loudness change in response to down-ramp stimuli. In music, continuous changes of acoustic intensity are closely associated with listeners' perception of both loudness change and affective arousal. Two experiments reported here investigate perceived loudness change in response to melodies that increase (up-ramp, crescendi) or decrease (down-ramp, decrescendi) in acoustic intensity, and the interaction with other musical factors such as melodic contour, tempo, tonal familiarity, and dynamic context. Specifically, a within-subjects design manipulated direction of intensity change (up-ramp, down-ramp), melodic contour (ascending, descending), tempo (64.8 bpm, 129.6 bpm), tonality (tonal, atonal), and dynamic context (single-ramp and paired-ramp trials). Twenty-nine (Exp 1) and 35 (Exp 2) participants rated loudness continuously in response to monophonic 13-note piano melodies lasting from 6.4 s to 12 s. Down-ramps were perceived to change significantly more in loudness than up-ramps in both tonalities and at a relatively slow tempo. Loudness change was also judged to be greater for down-ramps presented with a congruent descending melodic contour, relative to an incongruent pairing (down-ramp and ascending melodic contour). No effect of intensity/melodic contour congruency was observed for up-ramps. In paired-stimulus trials assessing the possible impact of dynamic context, loudness change in response to up-ramps was significantly greater when preceded by a down-ramp, than when not preceded by another ramp. Dynamic context did not affect down-ramp perception. Phenomena from psychoacoustics and perception, principles of music composition, and performance of musical dynamics are used to interpret the results.

[2B-3.3] Auditory brainstem EEG, residue pitch, and nonlinear dynamical systems

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It is well-known that the auditory system is sensitive to the amplitude modulation of sounds. However, there are waveforms that have nearly-identical Hilbert envelopes but elicit different pitches. For example, a complex of equally-spaced harmonics of a fundamental has the same envelope as a complex shifted up or down by a fixed amount. The perceived pitch moves in the same direction as the frequency shift, but by a lesser amount. This "pitch shift of the residue" shows that the fine structure of a waveform plays a role in the auditory system's determination of its pitch.

Here we model both the physiology and perception of pitch with networks of neural oscillators. We used stimuli from Schouten et al. (1962), a pitch perception study, and Wile and Balaban (2007), a brainstem EEG study. These stimuli were constructed utilizing a technique that separates out the even-order from the odd-order nonlinear components in the brainstem response. This technique approximates the envelope-locked and fine structure-locked portions, respectively, of the response. In this study, three networks of tonotopically-spaced nonlinear oscillators were used to simulate the cochlea, the cochlear nucleus, and the lateral lemniscus. By weighting and filtering the summed network response with values reported in the physiological literature, we accurately replicate the frequency components found in the brainstem EEG. Further dynamical analysis showed the perceived pitch of both sets of stimuli to be a resonance of the fine structure-locked response. These results are explained as a consequence of highly nonlinear auditory processing.

[2B-4.1] Factors influencing tonality choice in song production

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Imagining the notes of a song entails mental representation of its key. Levitin (1994) and Halpern (1989) showed that many people remember the key of well-known recordings of a song. However, factors besides past hearings may influence the instantiation of a key. The present study used data acquired through the AIRS Test Battery of Singing Skills (Cohen et al., 2009; Pan et al., 2012) to explore key choice. In the study, young adults (19 musicians; 17 non-musicians) sang a familiar song, *Brother John (Frère Jacques)*, under 5 conditions: at the beginning of the session (prior to experimentally controlled musical influences); after presentation of a vocal model of the song in the key of C; in 4 phrases, each following a vocal model of the phrase in C; after hearing and attempting to recall an unfamiliar song in Eb; and after creating a short spoken story. The song *Brother John* repeats the tonic 10 times. Its average sung pitch (measured with Praat) was taken as the key-note. After presentation of the vocal model in C, musicians' mean key-note, as compared to non-musicians,' was significantly closer to C. After recalling the unfamiliar song in Eb, 11 (57.9%) musicians and 4 (23.5%) non-musicians chose Eb or Bb as the key; 3 (15.8%) musicians and 3 (17.6%) non-musicians chose C (the key of previous models); 1 (5.3%) musician and 4 (23.5%) non-musicians chose the key in which they first sang *Brother John*. Finally, after having created a spoken story, influence of the key (Eb) of the unfamiliar song decreased, while choosing a key either close to C or the original self-selected key increased. The study provides evidence of the value of using singing as a means of revealing global and local influences on the processes underlying tonality.

[2B-4.2] Hierarchies of cadential closure: Effects of training and context

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Although studies in music perception and cognition provide ample evidence for the importance of cadential closure in the experience of tonal music (Bigand et al., 1996; Bigand and Parncutt, 1999; Boltz, 1989; Cook 1987; Rosner and Narmour, 1992; Tillman et al., 1998), there remains a glaring lack of experimental evidence as to the cognitive processes involved in the perception of closure. In a previous study, participants provided completion ratings for perfect authentic (PAC), imperfect authentic (IAC), half (HC), deceptive (DC), and evaded cadenc es (EC) drawn from Mozart's keyboard sonatas. For the nonmusician group, the ratings demonstrated a descending hierarchy (PAC>IAC>DC>EC>HC), suggesting that the generation of harmonic and melodic expectations for the moment of expected cadential arrival accounts for the perception of closure during music listening. For the musician group, however, the ratings presented an entirely different hierarchy (PAC>IAC>HC>DC>EC), which suggests that musicians may also determine the completion of a given excerpt by virtue of the learned schemata for parameters *following* cadential arrival. Thus, the present study examines the effect of the formal context following cadential arrival on the perception of cadential closure.

Forty participants (20 musicians) heard 40 excerpts drawn from Mozart's keyboard sonatas that contained an equal number of each of the five cadence categories. However, for each stimulus the 5 s of material following cadential arrival was either retained (in context) or removed (out of context). After listening to each excerpt, participants rated the strength of completion for the moment of cadential arrival on a 7-point analogical-categorical scale. To orient the listener to the appropriate ending, a playback bar was presented on the computer screen that marked the cadential arrival.

Preliminary results suggest that the hierarchy of cadential strength demonstrated by the musician group ratings may reflect previous exposure to the formal context surrounding cadential arrival, suggesting that these categories may also achieve cadential status by virtue of the material following cadential arrival.

[2B-4.3] The effect of harmonic context on the perception of pitch class equivalence

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In general, the context in which a stimulus is presented shapes the way it is perceived. Context influences on stimulus perception have been extensively studied not only in visual perception, but also in speech perception and even taste (reviewed in Bigand & Tillmann, 2005). However, our understanding of how context affects pitch perception in musical stimuli is more limited. For instance, although tones belonging to the same pitch class (PC), such as octave-related tones, have long been known to exhibit strong perceptual similarity (Shepard, 1964), little research has been published on the influence of harmonic context on the perception of PC equivalence.

We investigated if, and how, harmonic context influences the perception of PC equivalence in musicians and non-musicians. The effect of harmonic context on the accuracy rates and reaction times of 19 musicians' and 19 non-musicians' judgments of PC equivalence was evaluated by sequentially presenting two probe tones, either in the absence of harmonic context or within a harmonic context of common major and minor chord progressions. Furthermore, the harmonic context could be the same for both tones, or it could differ.

The presence of a harmonic context decreased the accuracy and speed of recognition of PC equivalence, but only for musicians. Moreover, when tones belonging to the same PC were placed in the same context, judgments of PC equivalence were faster and more accurate than when tones were placed in a different context. When tones belonging to a different PC were placed in the same context, judgments of PC equivalence were slower and less accurate than when tones were placed in a different context. These findings suggest that tones and contexts are perceived as a gestalt: PC equivalence judgments are facilitated when both contexts and tones are the same, or when both contexts and tones are different.

[2B-4.4] Contextual expected development fraction model: Spatial-temporal framework for musical asymmetric interkey modulations revealed by subjective time estimations

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Musical tonal modulations between major keys elicit time estimations in inverse function of interkey distances with major impact of sudden ones. Distant reverse modulations shorten subjective time more than close ones. The present study found the following results: (1) modulations across the half or quarter of the counterclockwise side of the circle of fifths elicit shorter time estimations than across the clockwise ones; (2) modulations across the circle of minor thirds elicit shorter time estimations than across the circle of fifths; and (3) modulations between minor keys elicit time estimations in inverse function of interkey distances with major impact of sudden ones. In all these conditions, each participant listened to one music excerpt, was instructed regarding the time estimation task, and reproduced the corresponding music duration retrospectively and silently. Our previous Expected Development Fraction Model (EDF Model) claims that if an interkey distance is traversed, an expected development longer than the perceived duration is evoked; such disproportion is applied to that perceived duration, leading to shortening of time. This study extends the EDF Model to the Contextual Development Fraction Model (C-EDF Model) in order to contemplate all the keys and the spatial-temporal asymmetry in circles of fifths/minor thirds through the inclusion of the following factors: (1) the spatial axis for the set of 24 major and minor keys; (2) the gradient of asymmetry; (3) the medial effect which is weighted among the other local, global, and developmental ones; and (4) the after-stimulus decay-plus-interference process established between two devices, musical implicit working memory and visual-verbal time processor. Simulations confirmed predictions by the model. Albeit very influential for the parsimonious conception of C-EDF Model, other relevant music-cognitive, music-theoretic, time, and memory models of literature when singly taken may barely explain such set of data.

FRI

[2C-1.1] Relating subjective and objective measures of musical complexity in different musical styles

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Stimulus complexity is a poorly understood multidimensional concept that plays an essential role in aesthetic theories (Berlyne, 1971; Leder et al., 2004). The development of objective measures of complexity may offer new insights into the nature of perceived complexity. Current models of musical complexity based on audio feature extraction are intricate, computationally demanding and only moderately successful in predicting subjective complexity (Mauch & Levy, 2011; Streich, 2007). Here, we propose to adapt objective complexity measures based on compressed file size, which yielded moderate positive correlations with subjective complexity in the visual domain (e.g., Forsythe et al., 2011), to the study of musical complexity.

In Experiment 1, 36 non-musicians (18 females) listened to 92 25-second excerpts of Romantic piano solo music and rated familiarity, arousal, pleasantness and complexity on 7-point scales. In Experiment 2, another group of 40 non-musicians (20 females) rated a mixed set of 80 Romantic piano solo music and piano trio excerpts. To compare the performance of different measures, the original .WAV-files of the excerpts were compressed into MP3, FLAC and Ogg Vorbis files. Event density was calculated by using the MIRtoolbox (Lartillot et al., 2008).

Results of Experiment 1 indicated that FLAC compressed file size showed the highest correlation with subjective complexity (r_s = .65), followed by the MP3 format (r_s = .54). Event density also correlated highly with complexity ratings (r_s = .60). Moreover, strong correlations between arousal and compression size were observed (FLAC, r_s = .74 and MP3, r_s = .63), suggesting the potential use of these measures to capture arousal. Results of Experiment 2 corroborated those found for compression size in Experiment 1, whereas event density only yielded a moderate correlation with subjective complexity (r_s = .34). These findings suggest that compression size is a simple and efficient indicator of subjective complexity across sensory domains, which is particularly relevant for music information applications.

[2C-1.2] Listening devices and selection methods involved in everyday listening

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Digitization is changing the ways we consume music. The present two studies explored music listening in everyday life. In both, participants completed a questionnaire addressing demographics, technology use, and psychological constructs, such as identity, personality, and innovativeness. Study 1 focused on music-listening devices, and investigated whether technological and/or psychological variables could predict possession of a music technology identity, differences in the advantages perceived endemic to their preferred listening device, and whether preferring differing advantages was associated with the use of different listening devices. The results indicate the existence of a one-dimensional identity based on music technology and that psychological variables, such as innovativeness and self-efficacy, predict whether individuals have such an identity. Moreover, while psychological variables predicted whether individuals considered 'familiarized' advantages important to listening devices, preferring 'progressive' advantages was predicted by technological behaviors. Additionally, differences in identity and the preference for different advantages were evident on the basis of an individual's preferred listening device. Study 2 examined whether technology usage and/or psychological variables were related to individuals' tendency to select their music in three ways (specific choice, playlists, and shuffle). The findings support those of the first study in terms of identity and also demonstrated that a different pattern of variables predicted playlist listening from listening to music on shuffle. Moreover, certain types of playlists were more commonly created and individuals with a more present-focused time perspective were likely to employ playlists. This research indicates that in order to understand how people interact with music in everyday life it is insufficient to merely map the demographic characteristics of the individuals concerned or to know how much time people spend with different music listening devices. Rather, a further consideration of psychological factors was able to add significantly to our understanding of how participants accessed their music.

[2C-1.3] Learning about structural analysis from structural analyses

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Identifying boundaries and repetitions are tasks that are fundamental to music perception and to formal analysis. Trying to replicate listeners' analyses algorithmically is an active research problem, and solutions usually rest on basic assumptions about how listeners analyze music, including how they identify boundaries and repetitions. For instance, it is usually taken for granted that boundaries are found by noticing relatively large changes in a musical parameter. We empirically test how well this assumption accounts for actual musical analyses.

We use the SALAMI [Structural Analysis of Large Amounts of Music Information] corpus of 1,240 structural analyses provided by 9 listeners, all pursuing graduate music degrees. Although this data was not collected as part of a psychological experiment, we demonstrate the value of cautiously repurposing it as such. From the recordings, we compute a set of acoustic features related to timbre, harmony, rhythm, tempo and local key, each for a range of time scales, and derive from these a set of points where the recording is changing the most. We find that boundaries were nearly all indicated by changes in one feature or another, and that coinciding with several simultaneous changes increased a point's likelihood of being a boundary. However, such changes indicated countless other points not deemed boundaries by listeners. Occurring near an acoustic change is thus found to be a nearly necessary and grossly insufficient condition for a point to be perceived as a boundary.

The data also revealed differences between how often changes in different musical features at different time scales correctly indicated boundaries, and the genres for which boundaries were more or less predictable. In a final experiment, we compare boundary profiles generated from the novelty functions and from the annotations, and discover that a boundary's salience appears correlated to how acoustically novel it is.

[2C-2.1] Involuntary musical imagery while the mind wanders: An ESM study

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Involuntary Musical Imagery (INMI) or "earworms" refers to the common experience of a tune that comes to the mind without effort and then repeats by itself without conscious control. INMI shares characteristics with other forms of involuntary memories, including frequency, triggers and context. One of the common contexts reported to relate to INMI is when attentional demand is low and thinking is task-unrelated, commonly known as mind wandering. The aim of this study was to capture and study the occurrence of INMI in everyday life temporally close to its occurrence, while paying special attention to the individual's concurrent cognitive and mood states. Experience Sampling Methodology (ESM) was used whereby thirty-eight participants were contacted by text messages, six times per day for one week. At each prompt they reported any ongoing INMI and mind wandering episodes, information regarding their current activity, mood state, possible INMI triggers and mind wandering content. The resulting multivariate dataset, based on 1374 episodes, was analyzed using a Bayesian Network approach which enables the identification of dependencies within a set of variables as well as the testing of hypotheses regarding causal influences and directed structural relationships. The first network found suggests that the time of the day and concurrent activities represent a set of interrelated variables that influence the occurrence of both INMI and mind wandering, which, in turn, affects mood. A second network (only INMI episodes) revealed that the activity the person was engaged in and the type of cue, which triggered the INMI, determined the pleasantness of the INMI experience. A third network based on mind wandering episodes is currently under investigation.

Overall, the results until now confirm and quantify existing evidence but also provide new insights into both phenomena by linking concurrent activities, triggers, mood states, and emotional evaluation of the involuntary experience.

[2C-2.2] Differential influences of imagery abilities on music encoding and retrieval

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Performers such as athletes and musicians can improve their performance by imagining the actions or sensory outcomes associated with their skill. Auditory and motor imagery abilities influence musicians' memory for music learned in conditions in which auditory or motor information is missing or altered (Brown & Palmer, 2012). It is unknown whether imagery abilities modulate both memory encoding (during learning) and retrieval (during recall). We examined how auditory and motor imagery abilities influence pianists' learning and recall. Pianists learned novel melodies by listening without performing (auditory learning) or by performing without sound (motor learning); following learning, pianists performed the melodies from memory with auditory feedback (recall). One of three interference conditions (auditory, motor, or none) was presented either during learning or during recall (between-subjects factor). Recall accuracy (percentage of correct pitches recalled) and temporal regularity (variability of quarter-note interonset intervals) were measured at recall. Independent tests assessed auditory and motor imagery skills. Pianists recalled music more accurately following auditory learning than motor learning, and least accurately in motor interference conditions. Both auditory and motor imagery skills improved recall overall. Auditory imagery skills influenced recall accuracy when interference was presented at learning: Skilled auditory imagers recalled more accurately than poor auditory imagers, and higher auditory imagery predicted higher recall accuracy following auditory learning with interference and motor learning with motor or no interference. These findings suggest that auditory imagery abilities decrease vulnerability to interference and compensate for missing auditory feedback at encoding. Auditory imagery skills also influenced temporal regularity when interference was presented at recall: Higher auditory imagery predicted greater temporal regularity during recall in the presence of auditory interference. Motor imagery aided recall accuracy overall when interference conditions were presented at learning but not at recall. Thus, performers' imagery abilities had distinct influences on encoding and retrieval of musical sequences.

[2C-2.3] How do you control your earworms? Coping strategies for managing involuntary musical imagery

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Involuntary musical imagery, or the more colloquial term 'earworm,' describes the phenomenon whereby an auditory image of a musical memory repeats in the mind. Studies have detailed the prevalence of this ubiquitous form of spontaneous cognition (over 90% of people experience them at least once a week), as well as the phenomenology and predictors related to individual differences, such as musical behaviors and personality. At this point we turn our attention to a key question that has the potential to inform theorizing; what methods are effective in coping with these episodes?

The present study used qualitative analysis techniques to classify the earworm coping strategies reported by 831 individuals via an international online survey. The population sample represents a large cross-section of age and backgrounds in self-rated musicality and musical experiences. Grounded theory analysis was run by two independent raters to derive two independent visual descriptive models; 1) Commonly reported earworm coping strategies, and 2) all coping strategies that were rated as effective.

Preliminary results at the time of writing indicate that successful active earworm coping strategies include techniques of musical 'self-medication' as well as mental distraction and control practices, such as subvocal dialogue and meditation. The analysis also allowed for the identification of 56 musical extracts that people report are effective in expunging earworms without themselves becoming stuck in the mind.

These results contribute to cognitive theorizing about the nature of involuntary musical imagery and will form the basis for controlled behavioral tests of earworm coping strategies as well as ecologically valid experience sampling studies of earworm coping in prolific sufferers.

[2C-3.1] Comparing the perceptual structure of tabla strokes and bols

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North Indian tabla drumming uses a kind of timbral solfeggio in which spoken syllables, called bols, stand for different kinds of strokes. Patel & Iversen (2003, Proc. 15th ICPhS, Barcelona) tested the hypothesis that bol/stroke pairs share similar acoustic properties on 4 pairs of bols and strokes (Tin/Tun, Kat/Ghe, Tra/Kra, Ta/Dha) and found acoustic properties that varied concomitantly in bols and strokes for each pair. The present study extends their work by assessing the perceptual and categorical structures among all eight of the same bols and strokes in a population of naive listeners unfamiliar with the system. In Experiment 1, listeners performed a free classification task on 24 sounds comprising eight bols or eight tabla strokes produced by three different performers. Hierarchical clustering analysis revealed that the productions by different performers were grouped together for specific bols and strokes. On average, 7.7 classes of bols were formed, but only 5.1 classes of strokes with confusions among Tra/Kra/Kat and Ta/Tin. In Experiment 2, listeners made dissimilarity ratings on all pairs of bols or strokes produced by one of the three performers from Experiment 1, and the data were analyzed with the CLASCAL multidimensional scaling algorithm. Both sets of sounds resulted in 3D spaces. However, there were strong differences in the two spaces, suggesting different perceptual structures for them. Finally, in Experiment 3, listeners performed a matching-to-sample task in which the eight bols were exhaustively matched to the eight strokes or vice versa for the sounds of Experiment 2. Average matching accuracy varied from 17% to 82% across strokes (chance = 12.5%). Therefore some bol/stroke associations are more easily perceived than others when naive listeners are confronted with many different categories. We will discuss possibilities for how Indian tabla pedagogy leads to the clear association between bols and strokes for experienced musicians.

[2C-3.2] Remodeling Southeast Asian tunings

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Since the pioneering reports of Ellis (1884, 1885) and Stumpf (1901), studies of Southeast Asian tunings have been methodologically problematic. Abstract numbers, empirical measurements, indigenous claims, and perceptual responses have been conflated; generalizations, vague; sampling, selective. In contrast, the present account takes as its starting point a formalization of the Gestalt Grouping Principles of Proximity and Common Fate in order to analyze the most comprehensive published measurements of Southeast Asian fixed-frequency idiophone tunings (Surjodiningrat et al., 1993; Charoensook et al., 1997). The resulting analysis is consistent with a relatively modest, but falsifiable, set of models for the acoustically measured sizes of intervals between successive steps: specifically, for Central Javanese sléndro, 11111; for Central Javanese pélog, 1121112; for Thai 'equiheptatonic,' 1111111.

In these models, a) any interval whose hypothesized size (HS) is smaller than the HS of any other interval is also smaller in measured size (MS), but b) no two intervals of the same HS are necessarily the same in MS. For instance, in Central Javanese pélog, the MSs of all size-2 intervals (e.g., 2 and 1+1=2) are a) smaller than the MSs of all size-3, size-4, etc. intervals (e.g., 1+2=3, 2+1=3, 1+1+1=3; 1+1+2=4, 1+2+1=4, 2+1+1=4, etc.) and b) 'the same' only by virtue of analogical relationships, namely, by sharing 'smaller-than' MS relationships with precisely the same group of intervals.

According to these models, one can clarify similarities and differences in trans-cultural realizations of 'the same' piece in contrasting tunings (e.g., Hughes 1992). In particular, sléndro, the 'usual' pentatonic (Clough & Douthett 1991), and well-formed (WF) 5-tone subsets of Thai equiheptatonic and Javanese pélog comprise successively greater numbers of differences, ambiguities and contradictions (Carey 2003). Moreover, these models provide a basis for reframing experimental studies of inter-cultural responses to such tunings (e.g., Krumhansl & Perlmann 1996).

[2C-3.3] "Whistle While You Work": The influence of work patterns on music downloading

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In the summer of 2012 the author entered into a 5-year data sharing and cooperation agreement with the Nokia Corporation, with the objective of establishing a digital music lab at McMaster University dedicated to the analysis of the Nokia's vast music-download database from sociocultural and musicological perspectives. Nokia currently has online music stores in some 40 countries, representing all areas of the globe; in total, over 20 million tracks are available in all genres. The data provided by Nokia cover a five-year period from 2007 to the present, which allows music-listening patterns to be studied longitudinally and at a global level. The dataset contains hundreds of millions of metadata downloads, with information pertaining to country, (anonymised) user, date, time, artist, genre, subgenre, and so on.

This research focuses on the extent to which music downloading is influenced by patterns of work across twenty-four-hour, weekly and seasonal timescales. For example, in many nations there is typically a surge in music downloading on Mondays as people prepare for their working week and its associated commute. Across a twenty-four hour period music downloading peaks in the mid- to late evening as people relax and (presumably) unwind. In addition, a secondary peak occurs at midday, during the workday lunch hour. These and other related download patterns raise the following questions. How do the dynamics of the working day influence genre selection? What are the overall tempo changes across the working day? Are some genres/artists more suited to pre-work than to post-work situations? And how are downloading patterns influenced by the work and cultural practices of various countries?

The presentation will explore these and other questions, and in so doing will aim to illuminate the multiple ways in which music is used in relation to work across the globe.

[2C-4.1] The effects of score reading on music listeners' experience of unfamiliar pieces

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The present study examined whether the auditory expectations created by reading a musical score might affect listeners' experience of unfamiliar pieces of various genres. Fifty-two college students listened to five newly composed piano pieces under "score" or "no score" conditions. The pieces ranged from a Chopin-style prelude to a freely atonal piece with irregular rhythms. For each piece, subjects rated the overall performance quality, appropriateness of pianist's expression, and compositional merit, as well as their familiarity with genre, level of interest, and level of enjoyment. Afterward, subjects took a score reading proficiency test and indicated their total years of formal musical training. For minimally proficient readers (24), the score condition had significantly lower ratings on at least one parameter (enjoyment, interest, expressiveness, or compositional merit) for four of the five pieces. For highly proficient readers (14), the score condition had significantly lower ratings on at least one parameter (genre familiarity, interest, overall performance, expressiveness, or compositional merit) for two of the five pieces. For moderately proficient readers (14), the score condition had significantly higher ratings for the parameter of overall performance quality for one of the pieces, with the other five parameters following a similar trend. Both the moderately and the highly proficient readers had similar levels of musical training, so it is possible that performance on the score reading test, which measured ability to detect visual/aural discrepancies in a score reading task, might actually be a marker of detail-oriented vs. global score reading style. It is also intriguing to note that for highly proficient score readers, the only piece to receive higher ratings of interest, enjoyment, and compositional merit in the score condition was the freely atonal piece. Such a finding could indicate that the prediction effect, which posits that musical pleasure results from the fulfillment of subconscious musical expectations, also applies to the visual expectations created by score reading.

[2C-4.2] Because it sounds right: Schema-driven miscues in children's piano performance

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Motivated by an interest in conflicts between schematic and veridical expectations, we consider situations in which well-formed musical schemas appear to conflict with a notated musical context. We first examine errors commonly made by young piano students through data gathered by surveying a group of highly experienced piano teachers. We determine a class of these errors to be "miscues," in which schematic knowledge seems to override literal performance.

We then consider instances in which advanced amateurs and professional pianists face similar schema-driven conflicts and make performance decisions that consciously depart from strict adherence to the score. Finally, we note that the conflicts between schematic and veridical expectations are not always easily corrected. In fact, music teachers themselves often make the same errors when prompted to spontaneously play or sing a passage correctly, even after attempting to rectify those errors in lesson situations.

We queried a large pool of teachers and ultimately culled examples of children's errors from two piano teachers who had over 75 years of combined teaching experience and who had taught over 2,000 students between the ages of 5 and 18 years old. They independently submitted examples of errors that occurred often and were consistently replicated.

After eliminating examples in which motor coordination and physiological constraints drive the errors, we consider the metric, rhythmic and melodic implications of what we are labeling "miscues." Our study of these miscues suggests that the strong influence of particular schemas can override the way the music is being processed during reading and performance.

[2C-4.3] Shared understanding in jazz performance: A case study

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The aim in this case study was to explore the extent to which a pair of experienced jazz musicians understand what they have done together in the same way: whether they spontaneously generate the same descriptions of their performances and intentions, and when they do not, whether they agree with their partner's characterization of what happened and what was intended. A professional saxophonist and pianist who had never previously met improvised three versions of "It Could Happen to You" (with the instruction that the performances should be different from each other) on either side of a visual barrier, so that they never saw or spoke with each other. Immediately after, each player was interviewed separately about the three performances, first from memory and then while listening to recordings of the performances, so as to prompt specific and detailed commentary. In addition a jazz expert was invited to provide written commentary based on close listening to the recordings. From the interviews and the jazz expert's commentary all statements about the players, the performances, and their musical intentions were then extracted, for a total of 151 statements. Two months later, the performers listened to the recordings again and rated (on a five point scale) the extent to which they endorsed each statement (not attributed to either player or the expert). The performers endorsed statements they themselves had generated more often than statements by the expert or by their performing partner. Furthermore, the statements with the most disagreement included not only judgments of quality of performance, but also assessments of the nature of the collaboration and even basic facts about what happened. Results suggest that, at least in this case study, fully shared understanding of what happened is not essential for successful improvisation, and that the performers' interpretations may not be fully privileged relative to an outsider's.

Poster Abstracts

[2-01] The effect of attention and beat salience on selective neuronal entrainment to non-repeating rhythms

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The neural basis of beat perception (Grahn, 2009) has been explained in terms of resonance theory (Large, 2008), which suggests that neuronal firing patterns adapt to resonate with incoming stimuli. This effect has been shown recently using human electroencephalogram (EEG) to capture steady-state evoked potentials (SS-EPs; Nozaradan et al., 2011, 2012), although, these previous studies only used isochronous stimuli (Lakatos, et al., 2008) or repeated short rhythms (Nozaradan et al., 2012) ,and participants consciously attended to the stimuli. It is unknown whether enhanced, beat-related SS-EPs are evident with (1) non-repeating rhythms and (2) without attention to the stimuli. Here, we assessed whether neural enhancement of SS-EPs at beat frequency occurs when (1) rhythms did not repeat (i.e., the rhythmic pattern is unpredictable, and only the beat is predictable), and (2) when participants did not attend to the rhythms. If SS-EPs mark beat perception and not pattern prediction, enhancement at the beat frequency should still be evident with non-repeating rhythms. In addition, if beat perception requires attention, SS-EPs will only be enhanced at the beat frequency in the attended condition. Participants listened to 33 second rhythms consisting of 990Hz pure tones while a high density electrode array (128 channel EGI) recorded neural activity. Beat perception was manipulated by using rhythms in which the beat was easily detectable and rhythms in which the beat was obscured by altering specific tone onsets by +/- 60 ms. Attention was manipulated by distracting participants with a cognitively demanding visual task.

Preliminary results show enhancement of SS-EPs at beat frequencies in non-repeating rhythms. Although not as large as in the attended condition, SS-EPs are still present in the distracted condition. These results distinguish beat perception from pattern recognition and provide further evidence for SS-EP enhancement as a neurological marker of beat perception.

[2-02] Beta- and gamma-band electroencephalographic activity indicates pulse in non-isochronous syncopated rhythms

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Beta- and gamma-band electroencephalographic (EEG) activity as a neural representation of metric structure has been studied using isochronous sequences at different tempi (Fujioka, Trainor, Large, & Ross, 2012), with omissions (Fujioka, Trainor, Large, & Ross, 2009; Snyder & Large, 2005), and with timing perturbations (Zanto, Large, Fuchs, & Kelso, 2005). Complex syncopated patterns have been investigated using fMRI (Chapin et al., 2010), where activity in pulse-associated areas (i.e., basal ganglia and supplementary motor area [SMA]) has been observed, suggesting that an isochronous pulse can be extracted from a non-isochronous sequence. On the basis of this evidence, it seems reasonable to hypothesize that beta- and gamma-band oscillations should time-lock to the implied pulse in syncopated rhythms. Listeners were presented with standard and syncopated trials, each consisting of 3-tone cycles. For standard trials, the inter-onset-intervals (IOI) separating the three tones were 780ms, 390ms, and 390ms. For syncopated trials, the IOI's were 585ms, 585ms, and 390ms. This syncopated "3-3-2" rhythm strongly implies an underlying isochronous pulse (with an IOI of 390ms) despite only two of the three tone onsets being concurrent with the pulse. Time-frequency analysis of EEG in syncopated trials revealed that responses peaked at timepoints concurrent with the implied pulse and tone onsets, with latencies comparable to previous work (Snyder & Large, 2005; Zanto et al., 2005). These findings implicate beta- and gamma-band EEG activity in the perception of an implied pulse during a syncopated pattern. Since non-isochronous tone onsets are not oscillatory tracking them per se would go against the oscillatory nature of neuronal activity, making the case for tracking the implied oscillatory pulse.

[2-03] Dancing in the deaf: Beat entrainment through vibrotactile stimuli

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Anecdotal reports indicate that some deaf people enjoy dancing to music. Without auditory information, deaf people require non-auditory sensory information, such as visual cues from the dancers around them, or vibrotactile cues from the music, to synchronize their movements. Little is known on the effectiveness of these non-auditory cues in transmitting beat information, or on the beat-synchronization accuracy of deaf people.

As a preliminary exploration of dancing in the deaf, we tested the motor synchronization of early-deaf people to an auditory beat that was sensed through vibrations. We used two auditory stimuli: first, a bass metronome at 125 beats-per-minute, and second, a recording of a popular dance song.

Participants were deaf adults with congenital and profound hearing loss. They felt the vibrations of the auditory stimuli through an inflated party-style rubber balloon and synchronized a vertical bouncing motion to the perceived beat. We measured the vertical acceleration of this motion with a Wii controller attached to the participant's torso. Continuous data were analysed for period and phase locking accuracy.

To date, we have tested four deaf participants. Preliminary results indicate that three out of the four deaf participants are able to synchronize to the metronome stimulus. For the musical stimulus, these participants showed power at the beat frequency only when a strong bass beat was present in the song. These observations confirm that deaf people can use vibrotactile information for beat entrainment. Future analyses will compare the performance of deaf people to hearing control participants, who will experience the auditory stimuli through hearing.

[2-04] Auditory-Motor Integration in Cellists

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Auditory motor integration is a skill fundamental to activities such as speaking, singing, and playing a musical instrument. However, it is unknown what neural circuit governs this expertise. Zarate and Zatorre (2005, 2008) have addressed this issue using the voice as a model instrument. Voices, as well as non-fretted string instruments such as the cello, have a continuous pitch mapping. This means that, once a note has been produced, the pitch must be altered based on real-time auditory feedback. However, the voice relies on the muscles of the vocal apparatus. This system is evolutionarily old, and is used for speech and non-speech vocalizations as well as for singing. The auditory-motor mapping of the cello, on the other hand, is arbitrary and learned explicitly. For this reason we propose that studying cello players will provide novel information regarding auditory-motor control, which is complementary to that of the vocal literature.

This study aims to characterize expert cello players' motor response to pitch altered auditory feedback, and the neural correlates thereof. For this experiment, cello players were asked to listen to and, subsequently, produce a series of single notes on an electric cello. Auditory feedback was delivered to participants via headphones such that the experimenter could alter its pitch. Participants were asked to compensate for the pitch perturbations immediately. Their auditory output was recorded directly from the cello. These methods were designed such that they closely parallel those of Zarate and Zatorre (2005, 2008). The data from the behavioral task is currently being analyzed in order to determine the degree to which participants compensated for the pitch perturbations. We anticipate that they will show total compensation, as was the case in trained vocalists. An MRI compatible cello has been designed for use in the fMRI neuroimaging study, which will follow the behavioral investigation.

[2-05] Supplementary motor area (SMA) and auditory cortex activation in an expert break-dancer during visualized dance to music

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Investigating the neural activity underlying self-visualization of movement, we measured the blood-oxygen-level-dependent (BOLD) response in an expert break-dancer, KS, while listening to familiar break-dancing music (Incredible Bongo Band (Grandmaster Flash mix) - *Apache*), compared to less familiar ballet music (J.S. Bach – *Concerto in C major*). The SMA has shown distinct patterns of activation in response to visualization of familiar motor task, such as choreographed dance routines. Additionally, there is evidence that bilateral superior temporal lobes (STL) show similar patterns of activation during visualization of dance routines, particularly in the right hemisphere. Based on previous research from our lab, we expected to see increased activity in the SMA during visualization to familiar music when compared to an unfamiliar style, as well as a lateralization of activity in temporal lobes. Our results indicate that KS shows more activity in SMA during the familiar break-dancing music over the ballet music, additionally KS has a significantly more active SMA than an aged matched control. Compared to the control, subject KS demonstrated a significant lateralization of activity in the right STL while visualizing to the ballet music. These early results support the idea that familiar, highly trained motor sequences promote significant increases in SMA activity in subjects during visualization of dance to the music. Additionally, there is evidence that expert dancers show unique neural activity in the right superior temporal lobe when self-visualization to unfamiliar music and dancing styles. It is possible that this is associated to the subject's auditory search of the novel musical scene in their attempt to creatively generate improvised choreography.

[2-06] The motion and emotion of playing keyboard instrument by a professional and an amateur

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We focus on the motion of keyboard instrument performance. This study compered a professional and an amateur. Davidson found that head movement was important for pianist's expressive intentions. Castellano examined pianist's emotion and motion using the video recorder tracking. These results showed that velocity of head movement was important for emotional expression. Here we decided to investigate the difference between a professional and an amateur keyboard player with the basis of various emotions. Performers were asked to play a short piece of simple melody with expression of each five basic emotion–happiness, tenderness, anger, sadness, fear (Juslin and Sloboda, 2001) and non-emotion. The movement of this keyboard instrument performance was recorded by a motion capture system.

34 reflective markers were attached on a player's upper half of the body and keyboard. The multiple infrared cameras were used to detect the positions of these markers in three-dimensional space. The analysis section was from the first tone to last of the piano piece. The center of gravity was calculated as one index of upper body movement.

As the result of center of gravity movement distance, the emotionless was the shortest to movement distance for both players. And the happiness was the longest.

As the result of distances ratio of the happiness and the emotionless, a professional was 3.86. In contrast, an amateur was 2.77.We thought that professional make a contrast for emotional expression.

And it was smooth that the center of gravity waveform of a professional. In contrast, the amateur was not smooth. The amplitude waveform of a professional was wide and the period was long.

We thought that professional players would control their emotions using smooth movement of their center of gravity.

[2-07] Challenges from the perspective of a three-fold ontological continuum of music on mixed-media interactive environments exploring body-sensory perceptions

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Music, or organized sounds, can be predicated on three ontological dimensions: (i) the cogito/body-sensory perceptual continuum (ii) the sonic continuum, and (iii) the musical interface continuum. The complication of a three-fold ontological musical universe presents a set of challenges in the context of mixed-media responsive or interactive performance or participatory environments aimed to explore the phenomenology of perception as advocated by French philosopher Merleau-Ponty. In some of these phenomenological explorations, participants are encouraged to dwell in a continuous and prolonged state of responding with rich and meaningful gestures, movements and play on interacting with sonic media events. This phenomenological engagement partly draws an analogy of an inhabitant immersed in an elusive act of organizing sonic materials within the constantly morphing structure of a "musical interface." Examined under the three-fold ontological field of music, strands of sonic materials would often occupy a specific locality in that ontological continuum due to the transfiguration of the "musical interface" within a circumscribed limit that emphasizes gestural movements. It prompts one to investigate the possibility of potentially richer palettes of modulated gestures invoked if the sonic media were to be cajoled into venturing to other designations on the vast musical ontological continuum. Would it be necessary to reenact the conditions of the cogito/body-sensory paradox in such responsive environments to do justice to the phenomenological experience that strives to enlighten in the significance of bodily perception? If so, would that necessitate a richer configuration of sonic media to accommodate organized sounds spanning the cogito/body-sensory ontological space? Should we introduce more established forms of musical interfaces along with newly evolving ones? How should sonic materials conceived in the depth of the cogito (without any association to movement-based musical interface) be activated into a kind of manifestation that interacts with bodily gestures and movements of the participants?

[2-08] Music intervention as system: Reversing hyper systemizing in Autism Spectrum Disorders to the comprehension of music as intervention

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This paper seeks to combine the notion of the empathising-systemising (E-S) theory and the resulting twist from the executive dysfunction theory in autism spectrum conditions in light of music intervention as system.

To achieve these points it will be important to re-visit, nonetheless briefly, the above mentioned theories and re-define music intervention in view of these. Our understanding of autism in light of impaired neuropsychological functions, calls for alternatives in the improvement of quality of life for these individuals, moving away from still more disabling pharmaceutical intrusions. Music intervention offers this alternative through its multifaceted cognitive stimulation, lacks however a unified and applicable model. Against this backdrop there is the need to adjust the executive dysfunction theory to a theory of dysfunctioning executive functions (dEF) to understand music intervention, E-S and the mentioned dEF. This in turn allows an insight into the cognitive workings of music on the autistic spectrum.

These notions - based on case reports of both clients and therapists as-well as systematic literature reviews - will create a different understanding of music intervention in this framework, placing the grounding stone in the development of future and existing music intervention programs applied clinically. These applications will evolve around a structuralised approach to music intervention as system, proposing five consecutive systems. (Collectible, Mechanical, Numerical, Natural, Motor and Social). Each of these are holding specific attributes, which reflect behaviors on the autistic spectrum. It will therefore argue the aspects of expanding existing theories in ASD together with the call for generalised interventions to better assess autism.

Theories have to be updated in a time of fast and ever- changing development; a notion that this paper seeks to argue from a clinical, therapeutic, interventional, cognitive and theoretical point of view.

[2-09] Do older professional musicians have cognitive advantages?

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Previous research suggests that cognitively stimulating activities, such as a lifetime of using two or more languages, can result in preserved cognitive functioning in old age. These findings encourage the search for other types of stimulating experiences that can contribute to cognitive reserve and preserved cognition in older adults. The current study investigates whether long-term music experience can protect against age-related cognitive decline. Older adult professional musicians (N = 19, M = 59.84 years, SD = 7.51) and non-musicians (N = 24, M = 60.83 years, SD = 6.56), matched on age, education, vocabulary, and general health, were compared on a near-transfer task involving auditory processing and on far-transfer tasks that measured spatial span and aspects of cognitive control. Musicians outperformed non-musicians on the near-transfer task, on most but not all of the far-transfer tasks, and on a composite measure of cognitive control. The results suggest the possibility that sustained music training or involvement may preserve aspects of cognitive functioning in older adults.

[2-10] Sung presentation of lyrics enhances memory consolidation in mild Alzheimer's Disease

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We have shown that mild Alzheimer's disease (AD) patients have better mid-term memory (10-minute delay) for lyrics when these are sung rather than spoken. This statistically significant advantage for singing occurred after a single learning session. In a subsequent study, we studied the evolution of this advantage over several learning episodes. In a within subject design, the patients learned one spoken excerpt and one sung excerpt in separate sessions. Spoken excerpts were recited by a female speaker on a natural speech. Sung excerpts were simple songs in major mode, recorded by the same female voice without any instrumental accompaniment. The association between lyrical excerpts and presentation mode was counterbalanced across participants. Each excerpt was learned once per week over a period of 4 weeks. After a month delay, each excerpt was re-learned. Results show a similar increase of recall across the 4 weeks of learning for both singing and speaking excerpts. However, after the one month delay, most subjects only showed a significant advantage for the singing condition. This result confirms our previous findings and suggests that music may reinforce the consolidation process in long-term memory, despite the presence of memory impairment in AD. Possible ways to reinforce / increase this mnemonic effect of music will be discussed.

[2-11] 'Are they filthy rich?': A thematic analysis of the motivations behind recorded and live music purchases

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While recent piracy trends point towards a decreased willingness to pay for music, the increase in the popularity of live music suggests otherwise. There is a lack of research exploring this changing relationship between recorded and live music. While much is known about live music attendance motivators, little attention has been paid to motivation for purchasing recorded music. In the present study, the unique motivations for why music fans decide to 1) purchase recorded music and 2) go to live concerts is of interest. Data gathered from two open-ended questionnaires were analysed thematically and two key themes were identified for recorded music purchases: *Objective* and *Subjective*. Four key themes were identified for live music purchases: *Experience, Engagement, Novelty* and *Practical*. Where the unknown, novel aspects of live music were key

motivators, demonstrating live music as an 'experience good,' the known aspects of recorded music were markedly salient among participants. Here, value maximisation was a clear trend, with participants revealing considered decision-making processes to determine if a piece of recorded music was worth paying for and a consideration of recording artists' financial position. Concert ticket purchasing, by contrast, was more impulsive and seen as an opportunity to see favourite artists in the flesh with like-minded others. Results suggest it is this social dimension of the live music experience that may account for its recent rise in popularity, where much music listening now occurs in isolation. As well as building on research into music piracy, findings also shed light on more cultural changes in music listening as a result of technology. Discussion focusses on emerging consumer preferences during a period of flux in the music industry, and speculation on future trends.

[2-12] Listening online: Music and social network use

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Digitization and the Internet have altered the way we think of music consumption and consumer behaviors. In two studies, music related behaviors were considered in terms of broader social network site usage. For both studies, participants (N= 239 and 211, respectively) completed questionnaires online. The objective of study 1 was to explore technology use and psychological variables among those individuals who use social network websites to interact with musicians. Additionally, research questions considered whether these variables could predict who believed musicians should use social media to interact with fans and those who believe that such interactions influence their listening experiences. Preliminary indications are that that those individuals who approach using social networking positively, were early adopters, and who use social networks in a playful manner are those who believe that musicians should interact with their fans via social media. Additional analyses are currently being performed such that detailed results will be presented at the conference. Study 2 considered one popular social network in particular: Facebook. Specifically, the aim was to explore the use of music applications now available for use within Facebook's platform. This represents a new way of interacting with music, and after only a year, 62.6 million songs had been involved in 22 billion plays (Kirn, 2012). Adopting the uses and gratifications approach, a factor analysis identified seven reasons for using a music application. Moreover, data analysis is underway to examine whether music-related Facebook habits can be predicted by any technology behaviors or psychological variables (e.g., personality, innovativeness, self-efficacy, music engagement). Again, detailed results will be discussed; but in general, technology influences everyday interactions with music in a manner not seen hitherto, with particular implications concerning how individuals consume music as a part of their broader social media behaviors.

[2-13] Spontaneous synchronized tapping to an auditory rhythm in a chimpanzee

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Humans actively use behavioral synchrony such as dancing and singing when they intend to make affiliative relationships, and researchers have suggested that synchronous movement may serve as a cooperation-enhancing mechanism, binding individuals together into a larger whole. One recent study supports this hypothesis, showing not only that motor synchrony leads to increased cooperation on economic tasks, but also that individuals engaging in such synchrony show an increased sense of being in "a same team." However, the evolutionary origin of this ability of humans for advanced synchronous activities is unclear. Here we show that a member of our closest living relatives, a chimpanzee, spontaneously synchronizes her movement with an auditory rhythm. In the experiment, three chimpanzees were trained to tap illuminated keys on an electric keyboard. The light did not signal any rhythms because it switched to the next key immediately when the chimpanzees tapped the lit key. When one chimpanzee ("Ai") heard an isochronous distractor sound (i.e., ISI: 600ms), she spontaneously aligned her tapping with the sound. This result suggests that sensitivity

to, and tendency toward synchronous movement with an auditory rhythm exist in chimpanzees in common with humans. Absence of reports of explicit use of rhythm for social bonding in wild chimpanzees suggests that factors unique to human society, such as larger group size and/or complex vocal learning, may have expanded behavioral synchrony to unique forms of auditory and visual communication during the course of human evolution.

[2-14] Effects of music and dance education on working memory

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A body of evidence demonstrates that musicians perform better than non-musicians on various cognitive functions and general intelligence. Executive functions, such as working memory, are one proposed mechanism underlying this link, and have been associated with both music and intelligence. Since previous research has been largely correlational, randomized controlled designs are needed to investigate causal effects. The objective of this study was to assess the effect of music and dance training on working memory. Fifty participants, aged between six and nine, were randomly assigned to either music or dance/movement education, stratifying for age, gender, and non-verbal IQ. Both groups received a month of training, matched on duration, intensity, and delivery. Participants were tested before and after the training on two measures of working memory: digit span and the self-ordered pointing task. For each task, number of errors and span scores were calculated. Using active control groups will elucidate whether results are specific to one training domain. Preliminary findings from the forward digit span task show a significant improvement on performance following training, $F(1, 48) = 9.633$, $p = .003$, $\eta\rho^2 = 0.167$, with no significant effect of training group or interactions. Further analyses will be presented on the digit symbol task and self-ordered pointing task. Together, these data support recent findings on musical training and improved cognition, and indicate the causal role of training in this link. They also suggest that other training programs (such as dance education) may offer similar benefits.

[2-15] On the determinants of listening time for novel musical excerpts

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One implicit measure of how much a listener likes a piece of music is how long they listen to it before choosing to listen to something else. Although the amount of time spent engaging with a stimulus is a common measure of preference or familiarity in infant studies, and was utilized decades ago in aesthetics research, the potential of this simple appetitive measure seems underutilized in music perception research. Across three studies, we sought to determine musical and psychological factors that influence the amount of time a person listen's to a stimulus. Stimuli were polyphonic loops, consisting of 4 instrument parts, constructed from Apple Loops or composed *de novo*. Loop durations were 4–8 seconds, and participants were free to listen to each loop as long as they desired, up to a maximum of 2 minutes. Upon termination of each loop, participants rated how much they enjoyed the loops and endorsed reasons for choosing to stop listening to the loop and reasons for why they listened to each loop as long as they did. Across the 162 loops constructed for Study 1, all instruments entered synchronously and were heard the entire time. For Study 2, instrument entrances of 30 Study 1 loops with the longest, shortest, and intermediate listening times were staggered. For Study 3 we composed 40 core loops, and manipulated them further to (1) minimize harmonic variability, (2) minimize rhythmic variability, (3) introduce spatialization, or (4) change timbral characteristics. Overall, multiple regression and path analyses indicated that listening times were best predicted by increased variation in stimulus features and the desire/expectation for such variation, as well as by subjective enjoyment. Enjoyment was predicted by perceived groove, the urge to move, interest in the stimulus, and congruency with current mood.

[2-16] Musicians' movements for timekeeping: A link between tapping and musical experience

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We often bob our heads and/or tap our feet when listening to music, and our lab's previous research suggests that these movements may actually facilitate our understanding of music's temporal structure regardless of musical training (Manning & Schutz, 2011). However, previous studies demonstrate musicians' superior timing accuracy (Rammsayer et al., 2012) and superior tapping consistencies (Repp, 2010; Franek, et al., 1991) compared to nonmusicians. Therefore, our current study combines these two ideas to investigate the different effects of musical training on the variability of participants' timekeeping movements. Two groups of participants–highly trained musicians and students without musical training – judged probe tone deviations at the end of an isochronous sequence. Participants either tapped along to the sequence on a drum pad or remained still. After a short, silent interval participants judged whether a final tone was consistent with the previous sequence. We analyzed tapping variability (how consistently the participants tapped) with respect to years of musical training, finding a relationship between musical training and tapping ability. Our previous work illustrates greater accuracy in detecting timing deviations when tapping; however, here we show that expertise affects movement timing and subsequently may indirectly influence this phenomenon. Therefore these results inform our understanding of the interaction between musical experience and movement. If this tapping is enhanced through extensive experience, it may also influence timing perception. Overall, this study begins to extend our knowledge regarding the mechanisms involved in synchronization, expertise and human timing perception.

[2-17] Adding syncopation to simple melodies increases the perception of groove

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This study addresses the relationship between syncopation and groove in simple piano melodies. The principal motivation is to test whether creating syncopations in simple melodies increases the perception of groove in listeners. The basic stimuli comprised 10 simple piano melodies (around 20 s in duration), synthesized using MIDI at a fixed tempo of 100 BPM. Each melody was accompanied by a simple rhythmic pattern to provide a metric reference. These basic melodies were selected on the basis that they contained no syncopating events, and no note events at metrical levels below the quarter note. Each melody was transformed to create four different conditions: (1) "anticipation-syncopation" in which events at weak metrical positions were made one 8th note early, (2) "delay-syncopation" in which events at weak metrical positions were made delayed by one 8th note; iii) "max-syncopation," in which all events were one 8th note early, and (4) "density-transform," in which each event was halved in duration and the number of events doubled. The stimuli were presented to participants in a random order and ratings were collected for the following scales: movement inducing (i.e., groove), swinging, naturalness, preference and familiarity. Ratings were collected anonymously through a web-based experimental setup. Analysis of the data collected revealed a highly significant increase (Cohen's d' = 0.4) in the groove ratings for the syncopated melodies compared to the original quantized condition. A smaller effect size was observed (Cohen's d' = 0.25) when comparing groove ratings for the density and max-syncopation transformations to the quantized condition.

[2-18] Spontaneous sensorimotor coupling and the musical auditory scene

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Polyphonic music provides a complex auditory scene in which both acoustical and attentional factors may influence one's experience of a musical piece. Do listeners engage differently with musical scenes based on the temporal sequence of instrument part entrances? We investigated the effect of temporally staggered instrument entrances on one's urge to move, hypothesizing that multipart music with staggered part entrances would induce a higher degree of spontaneous movement than would music whose parts began simultaneously. Participants heard 40-s excerpts of novel, four-part music comprised of electronic dance music, folk, funk and rock. Instrument streams began either (a) simultaneously at the onset of the stimulus or (b) one after another in a staggered sequence. Participants were given the option to tap on the surface of a MIDI drum controller if the music compelled them to do so. We also recorded spontaneous head movements using an ultrasonic motion capture system. In addition to measuring the magnitude of spontaneous movement, we used a resonator-based metric profiling model (Tomic & Janata, 2008) to estimate the degree to which movements were entrained with the temporal structure of stimuli. We found that participants' tapping increased and became progressively more entrained following instrument entrances in staggered stimuli relative to simultaneous stimuli, especially for participants who tapped selectively (those who fell between tapping incessantly for all stimuli and not tapping at all). Participants also displayed greater spontaneous head movements and increased entrainment from one part entrance to the next, whereas stimulus-head movement entrainment plateaued during the latter portion of simultaneous trials. Together, the results indicate that temporal separation of instrument onsets in polyphonic music affects the amount and rhythmic quality of spontaneous movement. The results provide initial insights into the relationship between complex musical scenes and attentional engagement as manifested in spontaneous overt sensorimotor coupling.

[2-19] Does coordinated musical movement act as a social cue for 10- and 12-month-old infants?

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Making music is a collective human behavior; across every culture, groups sing, dance and play instruments together as a form of social unity. After participating in musical activities together, such as finger tapping or singing, adults are found to be more helpful and cooperative with one another. This effect of musical engagement on social behavior and communication also influences children. Children who participated in musical activities together will be more helpful and cooperative with each other than children who participated in a non-musical game together. To date, only one study has found such effects in infants; 14-month-old infants were found to be more helpful towards an adult after having engaging in synchronous musical movement with them. However, we do not yet know if infants younger than this use coordinated movement as a cue when directing their social behavior or, if not, when in development this effect emerges.

The current study seeks to investigate whether 10- and 12-month-old infants are influenced by coordinated musical movement in a social situation requiring them to make a preferential choice between two musical agents. Each infant was held in a child carrier while watching a puppet show. The infant was bounced to the beat of background music, while watching two puppets, each of which bounced in one of two ways: in-sync with the music or out-of-sync with the music. Following the puppet show, the infants were presented with both puppets, and allowed to choose by reaching for the puppet they preferred. The infant's overall looking time during and following each trial of the puppet show, as well as their ultimate choice, were used as measures of preference. Data collection is ongoing. The results of this experiment will indicate when this effect of coordinated musical movement on social behavior begins to emerge during development.

[2-20] Synchronizing body movements to the beat of music

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The ability to synchronize with music emerges spontaneously in childhood, without specific training. It is a complex process that builds on beat finding abilities that are expected to be wide spread in the normal population. To investigate this possibility, we tested 100 university students on several sensorimotor synchronizations tasks. The tasks involved hand clapping and full-body bouncing to the beat of pop, merengue, jazz and dance music as well as to a metronome click. Bouncing and clapping movements were recorded continuously with an accelerometer and analyzed for period and phase accuracy. So far, 75 participants have been tested and 5 have been identified as having synchronization deficits, by being 2 SD below the mean for period and phase-locking measures. These new beat-deaf participants were able to spontaneously produce movements at a regular tempo (without reference to an external pulse), suggesting that the disorder is not due to motor limitations. In addition to synchronization tasks, we tested our participants' beat perception with a task in which participants had to decide if short piano melodies were marches or waltzes. We found a small but significant correlation between synchronization performance and beat perception scores. Nevertheless, we found evidence of a dissociation between perception and production. No beat-deaf participants were impaired in beat perception whereas 6 participants who moved in synchrony with the musical beat performed poorly on the waltz-march test. These results suggest that beat perception tasks may not be appropriate for diagnosing beat deafness.

[2-21] The effect of pitch expectancy violations on timing of motor actions: A preliminary study

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When tapping in synchrony with an isochronous sequence of metronome beats, timing mechanisms are affected by expectancy violations of feedback sounds. Researchers have investigated the effect of violations in the expected timing of feedback (e.g., delayed feedback). Few researchers, however, have examined the influence of feedback content on timing (in this case, pitch). Understanding such effects may shed light on interactions in the processing of pitch and time, two principal form-bearing dimensions in Western tonal music. We investigated whether unexpected pitch perturbations interfere with the timing of motor actions in a finger tapping experiment. A synchronization and continuation paradigm was adopted whereby each tap in the continuation phase triggered a feedback tone. The pitch of the feedback remained constant except for a single tone (oddball). The oddball differed by 6, 13, or 23 semitones above or below the standard feedback tones. Participants were instructed to maintain the tempo established in the synchronization phase until the end of the trial and to ignore any changes in the pitch of feedback tones. The timing of finger tapping was significantly affected by unexpected pitch changes. The inter-tap interval (ITI) immediately following the pitch violation was significantly shorter, suggesting that unexpected pitch changes are registered earlier in processing, or that an arousal response to expectancy violation causes a transient increase in finger velocity. The effect observed was not affected by pitch distance or direction, although other research suggests that the extent and direction of pitch violation may be important for smaller changes in pitch (Ammirante, Thompson & Russo, 2011). Results demonstrate that the processing of spectral content interacts with mechanisms that control the timing of actions.

[2-22] Temporal coordination in piano duet performance of musical rounds

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In ensemble music performance, musicians must coordinate their actions with sounds produced by themselves and by others. The content and timing of auditory feedback is critical for control of solo performance, but less is known about the effects of self-feedback and partner-feedback on temporal coordination in ensemble performance. Ensemble performers must also keep track of the sequential order of events in their part and their partner's part, an especially difficult task in musical rounds, when their partner's actions match theirs at a temporal delay.

We addressed these questions in a piano duet task. Sixteen duet pairs performed isochronous melodies in each of three tasks: Solo (self-paced), Unison (pianists performed the same melody simultaneously), and Round (4-beat temporal offset between identical parts). Joint performances were initially metronome-cued. In joint tasks, pianists were assigned to the role of 'Leader' or 'Follower,' and auditory feedback was manipulated: Each performer heard full feedback (Full), or only feedback from their partner (Other). We compared the preferred performance style in solo performance (pattern of interonset intervals, IOI) with two measures of joint performance: asynchronies in tone onsets (Leader – Follower) and coordination between IOIs (cross-correlations).

Mean asynchronies differed across performance types: Leaders preceded Followers in Unison performances, whereas Followers preceded Leaders in Rounds. Cross-correlations were highest at lags +1 and -1, indicating that performers mutually adapted to each other. Lag +1 (Follower mimics Leader, 1 beat later) correlations were higher for 'Other' feedback than for 'Full' feedback, suggesting that Leader and Follower roles were exaggerated when self-feedback was removed. Performers whose IOI patterns correlated highly in Solo performances also had high lag0 correlations in joint performances, suggesting a shared interpretation. These findings suggest that performers' joint synchronization depends more on performance type, whereas joint coordination of temporal patterning is affected most by feedback and solo performance style.

[2-23] Synchronization, empathy, and prosocial behavior in children

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The human capacity to synchronize body movements and voices to an external acoustic stimulus (a behavior called rhythmic entrainment) enables collective music-making. When making music with others, individuals listen to one another, coordinate their movements, entrain to a common rhythm, and connect to each other's emotional state. It has been suggested that a possible adaptive function of sensorimotor synchronization in collective music making is creating group cohesion and can ultimately enhance empathy and promote prosocial behavior. We hypothesized that accuracy of synchronized movements during joint drumming in children, with and without musical training, is correlated with higher emotional empathy and prosocial behavior. We are currently testing this hypothesis by assessing two groups of children: (1) children between the ages 6 and 7 years at the onset of a collective music training program and (2) children between the ages 9 and 11 years with three years of collective music training. The music training is provided by a youth orchestra program (Youth Orchestra of Los Angeles), a socio-musical program based on the Venezuela approach known as El Sistema which emphasizes intensive musical ensemble participation from the early stages, group learning and peer teaching. We assessed children by asking them to drum along (1) with a recording, and (2) with an experimenter. Children were then tested with a battery focusing on assessment of emotional and cognitive empathy, theory of mind and pro-social behavior. Results analyzed so far confirm our prediction that, within each group, children with better abilities to adapt and synchronize their drumming with the experimenter outperform their peers on measures of empathy and prosociality. Complete results will be presented at the conference, along with a discussion on the emotional processes involved in musical interaction and the potential of ensemble musical training for fostering empathy and prosociality.

[2-24] The sound of silence: Attention entrainment to isochronous and syncopated beats

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Many types of music that we encounter have explicitly rhythmic and predictable patterns. Such predictable patterns in our environment have recently been implicated in the allocation of temporal attention. Specifically, research suggests that perceivers give maximal attention to anticipated events, both in the auditory and visual domains. Miller, Carlson, and McAuley (2013) have also demonstrated that attentional entrainment can occur cross-modally—that is, entrainment to a rhythmic auditory stimulus enhanced attention toward isochronous visual stimuli. Much of this research has focused on isochronous entraining stimuli, however in music we may experience non-present beats, as in syncopated rhythms. In these studies we test this distinction by entraining participants with either isochronous or syncopated rhythms. We found that participants entrained to the isochronous rhythm as expected, but entrained to both the imagined downbeat and presented tones in the syncopated conditions. This suggests that rhythmic entrainment is not solely a bottom-up process; it is mediated by prior knowledge about musical forms.

[2-25] Music tempo and its effect on a driver's risk-taking

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Past research has demonstrated that music tempo can influence an individual's behavior (Brodsky, 2002; Edworthy & Waring, 2006; Milliman,1982). It has been found that music tempo can influence a driver's mood and can be a source of distraction. Listening to music while driving may add to the driver's attentional load since listening to music requires the ability to process the words and sounds (Dibben & Willamson, 2007). In this study music tempo was investigated to determine its effects on risk taking. In a between-subject design, 80 participants completed a driving history questionnaire and then were assigned to 1 of 4 experimental conditions: no music (control), slow tempo, medium tempo and high tempo music. Participants were tested in a counterbalanced design using two measures of risky driving behavior: the Vienna Risk-Taking Test Traffic (WRBTV, a subtest of the Vienna Test System), a computer based driving program that measure's risk taking based on reaction times) and DriveSim, a computer-based driving simulator. As predicted, data from the WRBTV indicated that risk-taking increased as music tempo increased. The DriveSim simulator found significantly lower average speed and less speed deviation in the slow tempo group compared to the medium tempo condition. Significance was found between the low and medium tempo groups for speed and speed deviation. The medium tempo group displayed higher speed means and more deviance while driving than the low tempo group. Currently, there is scant research examining the effects of music listening on driving performance especially risk-taking. Further implications and future research will be discussed.

[2-26] Irregular meters and the binary rhythmic bias

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While binary meters are more prevalent than ternary meters in Western art music (Huron, 2008), it remains unknown if certain irregular meters are more prevalent than others. This project investigated both the prevalence and preference for either 5 beat or 7 beat metrical patterns. A preliminary study of 7 musical anthologies found that melodies with a 5 beat pattern were more common than melodies with a 7 beat pattern, χ^2 (1, N = 144) = 30.25, $p < 0.001$, $\phi = 0.46$. A follow up study investigated listener preferences for either 5 or 7 beat metrical patterns. Listeners were asked to listen to an assortment of rhythms, and then asked to rank their preferences for each rhythm using a 7 point Likert-scale. The results will address the authors' hypothesis that listeners tend to prefer simpler irregular meters (e.g., 5 beat patterns) to complex irregular meters (e.g. 7 beat patterns). Further, the results will address the notion of a bias for binary meter groupings in Western music.

[2-27] Effect of top-down imposition of a synchronized vs. syncopated downbeat on perceived duration of auditory oddballs

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Subjective time perception varies continuously throughout daily experience. The allocation of attention to events has been shown to influence their perceived duration. One way the relationship between attention and perceived duration has been studied is using an oddball paradigm, in which a deviant (oddball) event is presented amidst a sequence of identical (standard) events. Generally, the duration of the oddball is overestimated relative to the standards. In the present study, we investigate the possibility that oddball duration judgments are modulated by top-down imposition of a "downbeat" in an auditory oddball sequence. Participants heard a contextual-sequence followed in anti-phase by an oddball-containing sequence. The oddball could be heard as occurring either in syncopation or synchrony with the beat, depending on how participants were instructed to hear the sequence. We hypothesize that, if rhythm guides the allocation of attention (with stronger/weaker beats corresponding to increased/decreased attention) then oddballs heard in synchrony versus syncopation should be perceived as longer. On each trial participants in both synchrony and syncopation conditions heard a series of two five-tone isochronous sequences (IOI = 700-ms) separated by a 1050-ms silence. The contextual-sequence consisted of five 350-ms, 400-hz standard tones, and the subsequent phase-shifted oddball-containing sequence consisted of four standard tones and one variable-duration 700-hz oddball tone, in the 2nd-4th sequence position. At the end of each trial, participants judged whether the oddball was "shorter" or "longer" in duration than the standards. Preliminary results from musically-trained participants indicate 1) an effect of oddball sequence-position in a control condition in which no beat-imposition strategy was required (i.e., later-position oddballs perceived as longer in duration than earlier-position oddballs) and 2) a tendency in both the synchrony and syncopation conditions to underestimate the duration of the 2nd position oddball relative to the later-position oddballs.

[2-28] A comparison of rhythm discrimination ability in stuttering and non-stuttering children

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Stuttering is a commonly occurring neurodevelopmental disorder that affects the timing and rhythm of speech sound production. Similar to what is observed in Parkinson's disease, stuttering speakers have difficulty initiating movements that are self-generated, such as in spontaneous speech production. Consistent with the view that a basal ganglia-corticothalamic network is involved in rhythm processing, individuals with Parkinson's disease have been shown to demonstrate worse rhythm discrimination in simple rhythms when compared with age-matched controls (Grahn & Brett, 2009). In stuttering, even in the most severe cases, when external rhythmic pacing signals (e.g., metronome beats) are given and synchronized with speech, stuttering can be markedly alleviated (Alm, 2004; Toyomura, Fujii, & Kuriki, 2011). These findings suggest that stuttering speakers may lack the ability for internal generation of rhythm. The aim of the current study was to investigate whether children with developmental stuttering show worse rhythm discrimination for simple and/or complex rhythms compared to typically developing controls. The participants were 16 stuttering and 18 non-stuttering children ranging from 6.08-11.42 years of age. On each trial, the child heard two successive presentations of a standard rhythm (either simple or complex) and were then asked to judge whether a third (comparison) rhythm was the same or different from the standard. The task was presented in the context of a computer game, where colorful characters 'played' the test rhythms on a drum. The results showed that discrimination of simple rhythms was trending towards more accurate and significantly more sensitive than the complex rhythms. It was also found that stuttering children demonstrated lower performance and less sensitivity for rhythm discrimination than non-stuttering children; the stuttering children showed particularly poor performance on the complex rhythms. These findings suggest the possibility of rhythm processing deficits in stuttering speakers, and may shed light on fundamental deficits involved in stuttering.

[2-29] Effects of exercise-induced arousal on perceived and imagined tempi for familiar melodies

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The experience of replaying a familiar tune in one's head is a common and robust experience, which preserves many fundamental elements of musical structure. Tunes for which a canonical recorded version exists can be recalled highly accurately in regard to the original recorded pitch and tempo (Levitin, 1994; Levitin & Cook, 1996). Even for folk tunes that have no standard canonical version (e.g., "Happy Birthday"), individuals exhibit very stable representations of both pitch and tempo (Halpern, 1989). Preferred tempo for familiar tunes also appears to remain stable within an individual regardless of whether a tune is actually perceived or whether it is imagined (Halpern, 1988). The present project looks at the extent to which the internal timekeeping mechanism presumed to underlie these preferred tempo judgments can be modulated by physiological arousal, which is induced in our study through aerobic exercise. Preferred tempo judgments by participants in the exercise condition will be compared to a control group who complete a non-arousing, verbal anagram task. It is hypothesized that participants' tempo judgments for both perceived and imagined tunes will significantly increase following exercise-induced arousal, whereas the control group will show similar tempo judgments before and after the verbal task. Influences of participants' formal musical training and self-reported auditory imagery ability will also be investigated. The results of this study will provide evidence for whether this normally stable internal timekeeping mechanism can be altered by means of physiological arousal. If so, this would be an example of how bodily sensations can alter mental representations in a principled way.

[2-30] Studying the influence of music on motor coordination within the context of a dance game

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In a previous study investigating entrainment and person perception, in-tempo dancing with others was found to enhance memory for incidental person attributes (Woolhouse & Tidhar, 2010). A subsequent eye-tracking study (presented at this conference) investigated the possible mechanisms responsible for this finding. Two hypotheses were explored: that enhanced memory for person attributes is the result of (1) increased gaze time between in-tempo dancers, and/or (2) greater attentional focus between in-tempo dancers. Subjects watched videos of pairs of dancers in which only one of the dancers synchronized with the music, the other being asynchronous. The results were consistent with the first hypothesis: that music-dance synchrony gives rise to increased visual inspection (dwell/gaze) times. Results of inter-onset tapping intervals collected from the subjects as they watched the videos were analyzed to determine the possible effects of music-dance (a)synchrony on motor control.

To explore further the possible influence of music-dance (a)synchrony on motor control and coordination, the current study uses an XBOX 360 Kinect-camera system to investigate the ability of subjects to synchronize gestural dance movements with the projected image of a silhouetted dancer within the context of a game. (A strong motivation for using a game environment is to ameliorate the social inhibitions surrounding dance, particularly when undertaken within an 'artificial' lab setting.) In the experiment – presented as a game – subjects attempt to synchronize their dance movements with those of the projected dance silhouette. At various times the music is synchronized with the projected dancer, at other times the music is (surreptitiously) asynchronous. A control condition projects the dance image with no music. Subjects' performance accuracies are studied to determine the possible influence on motor coordination of music, and the conditions under which music either improves or degrades motor-control performance.

Saturday 10 August

Talk Abstracts

[3A-1.1] Experience-dependent modulation of feedback integration during singing: Role of the right anterior insula

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Somatosensation plays an important role in the motor control of vocal functions, yet its neural correlate and relation to vocal learning are not well understood. We used fMRI in 17 trained singers and 12 nonsingers to study the effects of vocal-fold anesthesia on the vocal-motor singing network as a function of singing expertise. Tasks required participants to sing musical target intervals under normal conditions and after anesthesia. At the behavioral level, anesthesia altered pitch accuracy in both groups, but singers were less affected than nonsingers, indicating an experience-dependent effect of the intervention. At the neural level, this difference was accompanied by distinct patterns of decreased activation in singers (cortical and subcortical sensory and motor areas) and nonsingers (subcortical motor areas only) respectively, suggesting that anesthesia affected the higher-level voluntary (explicit) motor and sensorimotor integration network more in experienced singers, and the lower-level (implicit) subcortical motor loops in nonsingers. The right anterior insular cortex (AIC) was identified as the principal area dissociating the effect of expertise as a function of anesthesia by three separate sources of evidence. First, it responded differently to anesthesia in singers (decreased activation) and nonsingers (increased activation). Second, functional connectivity between AIC and bilateral A1, M1, and S1 was reduced in singers but augmented in nonsingers. Third, increased BOLD activity in right AIC in singers was correlated with larger pitch deviation under anesthesia. We conclude that the right AIC and sensory-motor areas play a role in experience-dependent modulation of feedback integration for vocal motor control during singing.

[3A-1.2] Decoding neuroplasticity: Short–term musical training enhanced brain diversity and complexity

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Neuroplasticity is the process by which the environment is invited to influence brain structure and function. Music is a complex processes and, accordingly, musical training is associated with diverse brain changes (Hyde et al., 2009). Functional changes in neural activity can be observed after only a few hours of training (Pantev et al., 1999), passive musical exposure (Trainor et al., 2011), and auditory improvements correlated with degree of neural enhancement following musical training (Moreno et al., 2011; Schellenberg, 2004). Furthermore, musical training has shown transfer effects to other domains, most consistently verbal intelligence (Moreno et al., 2011), which is consistent with the idea that musical training has widespread neural effects. Experiments such as these have had an important impact on our understanding of brain-environment interactions; however, they have yet to describe a whole-brain mechanism of neuroplasticity that could support a range of cognitive changes.

Cognition is achieved through activation of transient neural networks, and a brain that has a wider range of

dynamic network configurations can support a wider range of cognitions and behaviors (Schellenberg, 2004). The extent of this range can be indicated by measures of *brain signal complexity* (McIntosh, 2000; Tononi & Edleman, 1998). We employ Multiscale Entropy (MSE) in the present experiment as our measure of brain complexity (McIntosh, 2010). MSE quantifies the predictability of the brain signal, or any other time series, and has previously been shown to change with maturation and aging to correlate with stable behavior (Tononi & Edelman, 1998), and correlate with cognitive task performance accuracy (Costa et al., 2002). Children in our study underwent 20 days of musical training (Moreno et al., 2011). Post-training EEG recordings displayed higher MSE during music and language tasks. This effect was robust in a wide range of neural regions; including temporal, cingulate and PFC. The results of this study suggest that musical training increases neural flexibility to support trained and untrained behaviors.

[3A-1.3] Differences in grey matter between early-trained, late-trained, and non-musicians using a multimodal approach

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The idea of a sensitive period for musical training has been proposed (Bailey & Penhune, 2010; 2012). Early-Trained (ET) musicians have demonstrated enhanced sensorimotor synchronization abilities compared to Late-Trained (LT) musicians, even when matched for years of musical experience (Watanabe et al., 2008; Bailey & Penhune, 2010; Steele et al., 2013). However, the underlying differences in grey matter have yet to be explored. In this study, ET (N =15) and LT (N = 15) adult musicians, matched for years of musical experience, were compared on a Rhythm Synchronization Task (RST), cognitive subtests and grey matter structure. A group of Non-Musicians (N=20) were included as a control group. T1-weighted images (32 channel head coil; 1x1x1 mm3) were acquired in a Siemens 3T scanner. Differences in grey matter were analyzed using three VBM-style techniques: traditional VBM, optimized VBM and Deformation-Based Morphometry (DBM). In addition, grey matter differences were analyzed using surface-based measures such as cortical thickness and surface area. Behavioral analyses revealed group differences on the RST, such that ET were better able to reproduce the temporal structure of the rhythms than LT and both musician groups outperformed the Non-Musicians. There were no significant group differences on the cognitive subtests between ET and LT musicians. DBM analyses yielded a group difference between ET and LT in the ventral pre-motor cortex. Extracted surface-based measures from this region of interest (ROI) suggest that this DBM difference is being driven by greater surface area in the ET. Correlations between all grey matter measures extracted from this ROI across participants reveal an interesting pattern. These results provide additional evidence supporting the idea of a sensitive period for musical training and will be discussed in the context of existing literature regarding multimodal approaches.

[3A-1.4] Formal music training and the developing brain: A preliminary report from a longitudinal study

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Several studies have provided compelling evidence that the brains of adult musicians are different from non-musicians in function and anatomy. These differences may be due to genetic influences or to other biological factors, may result from intense and systematic training during a critical period of development, or, most likely, a combination of both. The proportional contribution of these factors remains elusive. To address these issues we have designed a longitudinal study on the effects of systematic musical training in children on brain, cognitive, and social development. We assessed 20 children between the ages 6 and 7 years at the onset of their intensive musical training and will follow them for 5 consecutive years in order to explore how music affects their neural, cognitive, and social development. The musical training group consists of children training with the Youth Orchestra of Los Angeles,

a sociomusical program based on the Venezuelan approach known as El Sistema. As comparison groups, we studied a group of children involved in high intensity sports training and no musical training as well as a third group with no systematic training of any kind. Children were tested on a series of behavioral assessments (visual-spatial, non-verbal and verbal reasoning, emotional and social development, motor and musical), and underwent magnetic resonance imaging (MRI) and electroencephalography (EEG). The testing battery specifically included assessments of empathy and pro-social behavior.

The data analyzed so far indicate that the children participants fall within the normal distribution of the previously reported findings with regards to neural, cognitive, motor and musical abilities. These baseline findings lay the groundwork for the ongoing longitudinal study. Results from brain imaging, behavioral and musical tests will be presented at the conference, along with a discussion on their implications for the subsequent stage of the investigation and future studies.

[3A-1.5] SIMPHONY: Studying the impact music oractice has on neurodevelopment in youth

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We present the design and initial first year results of the 'SIMPHONY' study, a five-year longitudinal project to study the impact of music training on children within a neurocognitive framework designed to understand how the environment, genetics and brain interact during child development. The project is designed to contribute to ongoing nature vs. nurture debates regarding the origin of brain changes observed in adult musicians. We will study sixty children (age 5-10 at study start) yearly for a period of five years using an extensive battery of cognitive and developmental test instruments, the imaging of brain structure and connectivity, and genetic characterization. The project addresses the question of specificity by comparing children undergoing intensive instrumental music training (in the San Diego Youth Simphony's El Sistema inspired Community Opus Project) to two control groups: children not receiving music training, and children actively engaged in martial arts training. With longitudinal data, we will test the hypothesis that music training accelerates cognitive and neural developmental trajectories, and attempt to draw brain/behavioral links by examining how any observed behavioral changes are mirrored by changes in brain structure. To date, fourteen music-learners, five martial arts learners, and thirty-eight control children have completed the first year baseline measurements. We will present an initial cross-sectional analyses of performance on cognitive tests of beat perception and production (the Beat Alignment Test, Iversen & Patel, 2008), and melody and rhythm discrimination (Gordon tests of music audiation) describing how beat perception and production scores vary with age, and how they may relate to measures of other aspects of cognitive performance and brain structure.

[3A-2.1] Schachter's "tonal rhythm," the grammar-to-rhythm mapping in music, and its relation to linguistic PF

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An *externalist* position on musical rhythm asserts its independence from pitch structure. This position has been widely accepted, e.g., in Lerdahl and Jackendoff's famous separation of grouping and meter, in the different cognitive and neural mechanisms asserted for pitch and rhythm, and in the ethnomusicological emphasis on the ubiquity of rhythms around the world, often understood separately from pitch and/or in the context of 'pitch-external' phenomena like dancing. But rhythms often betray a regular, and usually binary (i.e., duple/quadruple), organization when understood in terms of their deeper, hypermetrical structure, and it is unclear if this deeper rhythmic regularity is the result of external constraints such as those imposed by dancing. In this light, the paper proposes an *internalist* explanation for rhythmic organization, i.e., in terms of its governance by pitch phenomena. In particular, it proposes a Schenkerian explanation for hypermetrical regularity, as the internalist attempt to relate aspects of musical surfaces to their deep pitch-structural foundations is the central contribution of Heinrich Schenker's

theories. The paper argues that grammatical processes in tonal music, when seen from a Schenkerian perspective, lead to binary phrase structures, such as antecedent-consequent pairs. Extending Carl Schachter's notion of "tonal rhythm," the rhythm inherent in tonal structure, the paper describes how the tonal rhythm inherent in binary phrase structures yields binary hypermetrical groupings too (such as eight-bar periods and sentences), deviations from these norms being the result of other pitch-grammatical processes such as phrase expansion. This suggests a mapping between pitch grammar and rhythm in tonal music due to their shared binarity. Amazingly, Chomskyan generative linguistics proposes an identical mapping between *linguistic* grammar and rhythm (i.e., prosody), at a level of linguistic sentence structure called Phonetic Form (PF). The paper develops this point, to end with the internalist suggestion that music and language might be identical.

[3A-2.2] Music intervals in speech: An interpersonal approach

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In recent decades, increasing attention has been paid to the role of musical-logic phenomena in human communication. This paper explores the relationship between real-time empathic interactions and musical intervals contained in their participants' speech vocal prosody. Working on the basis of Phonetic Convergence, it was expected that a two-party empathic interaction would translate into mathematical ratios similar to musical intervals between the Fundamental Frecuency (F0) of its participants. To this end, conversations of 12 participant dyads (Mean age = 20 years old) assigned to two experimental conditions defined as Empathic and Non-empathic were analyzed. Conversations from both conditions were guided by mutually answering a series of proposed questions adapted from the Fast Friends questionnaire (Aron et al., 1997). Mathematical ratios were obtained through the pairing of both speakers' F0 modes (mode considered as the most present and stable frequency) corresponding to conversations elicited by the mentioned questions. Next, such ratios were compared by condition through descriptive and inferential statistical analysis whose results support the initial hypothesis. Differences were found between conditions in terms of distribution of musical intervals smaller, or greater or equal than a Minor Third [$\chi^2(1)=4.7652$, $p=0.02904$]. These results are consistent with previous studies on the subject and not susceptible to be explained by differences on the individual members of each condition's prosodic characteristics [$t(22)=0.5583$, $p=0.5822$]. On the contrary, they seem to be a genuinely interpersonal phenomenon, which holds close relationship with the psychological quality of the human communication they emerge from.

[3A-2.3] Perception of the tritone paradox among Cantonese and Mandarin-speakers

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The phenomenon of the tritone paradox has been known as the first ever demonstration of how music perception was influenced by the language experience of listeners (Deutsch, 1991). When presented with Shepard tones that are separated by the interval of a tritone, listeners from different language backgrounds would perceive the direction of the tritone pair differently; some perceive the pair as ascending while others perceive it as descending. It was found that the tritone paradox was perceived consistently along the pitch-class circle, thus giving rise to the hypothesis that language would affect the orientation of the listener's internal pitch-class template. Moreover, Deutsch (2004) has reported that the orientation of this pitch-class template could be influenced by the exposure to another language at a young age. Besides this pitch class effect, Repp (1997) also argued that the perception of the tritone paradox is also heavily influenced by the position of the spectral envelopes of the tritone pairs.

In the study to be reported, the effects of pitch class and the position of spectral envelopes on the perception of tritone paradox among Cantonese and Mandarin-speakers are investigated. My experimental data shows that Cantonese and Mandarin speakers demonstrate two distinct pitch-class template orientations. Cantonese speakers from Hong Kong, who also learned British English at a young age, show affinity to the pitch-class orientation

of British English speakers. Also, the effect of spectral-envelope position is found in all subjects, but Mandarin speakers have shown a stronger resistance to the effect of spectral envelope than Cantonese speakers. Moreover, subjects with absolute pitch show no advantage in the consistency of perceiving the tritone paradox, thus suggesting that the effect of spectral envelope might be more influential than the effect of pitch-class in perceiving the tritone paradox.

[3A-2.4] Japanese EFL learners' likeability of popular English songs and perceived usefulness for the language classroom

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According to Bloom (1956), learning can be broken into three domains: cognitive, affective, and psychomotor. Similarly, Del Campo (1997) dissects music into three basic elements: melody (intonation), verse (words), dance (body language). The parallel between these two systems is apparent. Thus, the researcher sought to uncover parallels between how useful Japanese university EFL learners felt particular songs were to study in the language classroom, and their perceived impact on affect and cognition. Additionally, he analyzed perceptions towards mood, style, rhythm, tempo, clarity, memorability, likability, and overall language level of song content. The researcher applied a grounded theory approach, in which a 12 question survey was administered for each song in the study. Each question had a quantitative (Likert scale) component, as well as a qualitative (anecdotal comment) component, to determine emerging patterns. Additional attention was paid towards gender and song preference. Forty first year Japanese university students took part in the study: approximately, half male; half female. Twelve songs were chosen for analysis based on popularity on Wave-FM (a local Tokyo radio station) over the past year. Of these songs, a variety of styles were picked with an equal balance between male and female vocals, as well as a mixture of keys and tempos. Further, modal and tonal melodies were investigated, as Oura and Hatano (2004) demonstrated Japanese students find contemporary tonal melodies easier to remember than traditional Japanese modal melodies. They suggest this phenomenon could be due to exposure, or lack thereof. The researcher, in the current study, wished to ascertain whether such trends could also be transferred to memorability of L2 (second language) songs, making one mode more useful for language learning than the other. Results of the study will be given in a short talk, followed by suggestions for future research along with a chance to ask questions and make comments.

[3A-2.5] Stress-meter alignment in French vocal music

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This paper brings musical evidence to bear on a contentious linguistic issue: the nature of stress in French. Some have maintained that French has lexical stress on the final syllable of each word; others have argued that French has no lexical stress, only phrasal stress. A possible source of evidence on this issue is vocal music. In languages with lexical stress, such as English, it is well known that stressed syllables tend to occur at "strong" positions in the musical meter (some evidence will be presented supporting this view). A corpus analysis was performed to investigate the degree of stress-meter alignment in French songs. The analysis showed that (excluding syllables at the ends of lines) the final syllables of polysyllabic words tend to occur at stronger metrical positions than non-final syllables of those words; it also showed that monosyllabic content words tend to occur at stronger positions than monosyllabic function words. While conflicts between stress and meter are much more common in French than in English vocal music, our results suggest that French poets and composers recognized distinctions of stress between syllables of polysyllabic words, and between monosyllabic content and function words.

[3A-3.1] The theory, practice, and measurement of Music Therapy: Developing evidence from diverse practice

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Music therapy is a clinical healthcare discipline that draws its evidence base from music neuroscience and psychology to improve the health and well-being in individuals from varied clinical populations. Working with individuals across the lifespan, evidence-based therapeutic methods are developed from an understanding of music perception and cognition. Given the diversity of practice, there are several key challenges for the discipline. One is developing a theory-based clinical and research approach. This supports a deeper understanding of the complex music stimulus and therapeutic interactions that occur in a session. A second challenge is establishing means for evaluating the effects of intervention using neurophyisiological and behavioral measures. Issues of practice and measurement are confounded by the complex presentations typical of many of the populations that are frequently the focus of interest.

This symposium will bring together some of the latest research from the discipline of music therapy relating to the clinical needs of complex neurological and psychiatric populations. The papers offer diverse perspectives reflecting interdisciplinary influences on the theory and practice of music therapy including measurement and developing a theoretical framework. We will cover assessment and rehabilitative approaches with adults with disorders of consciousness, Huntington's disease and depression, and children who are at-risk neurodevelopmentally. The symposium aims to stimulate dialogue with the neuromusicology community in order to heighten awareness of the clinical challenges faced in the course of applying evidence in the theory, practice, and measurement of music as a clinical tool.

[3A-3.2] The development of evidence based Music Therapy for disorders of consciousness: Comparing healthy neurophysiological responses to individuals in vegetative and minimally conscious states

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Disorders of consciousness (DOC) comprise a continuum of predominantly acquired conditions. Distinguishing between DOC categories of vegetative state (VS), where there are no indications of consciousness despite evidence of wakefulness, and minimally conscious state (MCS) where consciousness is limited, is a challenging process. With awareness often masked by perceptual or motor impairments, misdiagnosis rates remain high. Music therapy assessment holds the potential to elicit responses despite damage to verbal or visual processing faculties, although robust empirical studies are lacking. To underpin this work with objective scientific data, a multiple baseline within subjects study comparing EEG, heart rate variability, respiration and behavioral responses of 20 healthy controls with 12 patients diagnosed as VS and 9 as MCS was conducted. Controls and patients were presented with contrasting music conditions (live salient music & improvised music entrained to respiration), recordings of disliked music, white noise and silence. Neurophysiological and behavioral measures were recorded using a 32 channel XLTEK© video EEG system, with a piezoelectric respiratory belt, and analysed using MATLAB, EEGLAB and BrainVision Analyzer 2 software. One way repeated measures ANOVA analysis of respiration, and power spectra analysis of EEG data indicated a range of significant responses ($p \leq 0.05$) across controls corresponding to arousal and attention in response to live music, including concurrent

increases in respiration rate with decreases in respiration variability. Similar findings within EEG data for controls and both VS and MCS cohorts, combined with significant findings for behavioral measures across the VS cohort, indicate music therapy is able to increase arousal levels for DOC patients, optimising the conditions for accurate assessment. Research is indicated to explore both the use of bio-markers of awareness and longer term effects upon neuroplasticity in response to music therapy within this population.

[3A-3.3] A theory-based conceptual framework for the selection of music stimuli for premature infants

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Neurobehavioral functioning is on a continuum with gestational age. Premature infants do not have fully developed biological, physiological, or neurological systems and complete their early development in an environment that is unintended for such important processes. Thus their neurological development differs from full term infants. Premature infants are reliant on medical and developmental interventions to appropriately support their neurodevelopmentally at-risk systems. Stimuli that are too complex and intense can have a negative impact on neurobehavioral development. It is important to understand the relationship between neurological functioning, behavioral outcomes, and the intervention stimulus for premature infants. Due to the variable characteristics of the musical elements and individual behavioral responses, music is a complex behavioral intervention strategy. The relationship between musical elements, brain function and gestational age (GA) is critical to understanding the role of music in neurological development of the premature infant and appropriate selection of music-based stimuli. Few studies or clinical models identify a well-defined theory or rationale for the selection of the music-based stimulus with premature infants in practice or research.

This paper will present a theoretical conceptual framework that identifies the therapeutic function of music (TFM) as a potential mechanism of change on the neurologically at-risk premature infant. The conceptual framework is formed from an integrated review of fetal, premature and infant literature on neurological processing of musical elements, cognition and perception of sound, and developmental psychobiology. Preliminary results indicate that music stimuli presented to neurodevelopmentally at-risk premature infants should have the following characteristics: a smooth, descending, single melodic contour with limited attack and pause; hummable pitch range no higher than E4; no accompaniment; slow, repetitive patterns with steady adagio tempo; no lyrics before 32 weeks GA; introduced only as the infant is able to process without physiological and behavioral stress indicators.

[3A-3.4] The Music Therapy assessment tool for awareness in disorders of consciousness: A measure for populations with disorders of consciousness

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As consciousness cannot be directly observed, the assessment of patients with disorders of consciousness (DOC) remains a clinical challenge. Although imaging methods provide greater objectivity in measures of awareness, uncertainty about the accuracy of diagnoses resulting from such tests confirm that behavioral assessments are the preferred method at the current time.

Developing reliable and valid behavioral assessment measures in DOC is challenging due to the severity of disability typical of the population: a combination of motor, sensory and cognitive impairments can mask residual functioning thus risking misdiagnosis. The auditory modality has been the focus of empirical inquiry

as evidence indicates that it is the most sensitive modality for identifying awareness. Furthermore, music is receiving increasing attention as a stimulus for assessment of awareness given its properties of being a non-language based stimulus within the auditory modality that has emotional saliency.

The Music Therapy Assessment Tool for Awareness in Disorders of Consciousness (MATADOC) was developed specifically for use with adult DOC populations admitted to interdisciplinary rehabilitation units for diagnosis of awareness. In a prospective study with repeated measures, we examined the MATADOC's internal consistency, inter-rater and test-retest reliability, dimensionality and concurrent validity with an external reference standard. The principal subscale showed satisfactory internal reliability (α=0.76) with inter-rater intra-class correlations (ICCs) ranging from 0.65 – 1.00 and intra-rater ICCs from 0.77 – 0.90. Rasch analysis confirmed these impressions of the principle subscale being a reliable, unidimensional and homogenous scale. Diagnostic outcomes had 100% agreement with a validated external reference standard ($p<0.001$) and were distributed across VS and MCS diagnoses indicating sensitivity to differentiating between the two subgroups. The MATADOC principal subscale provides a new behavioral measure for assessing responsiveness to musical stimuli and contributes to interdisciplinary awareness with DOC patients. The results of the overall measure are discussed considering the balance of clinimetric utility versus psychometric properties.

[3A-4.1] Good data practices and replicability in music perception and cognition

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Recently, a series of public scandals involving falsified data have thrust psychology into the public spotlight, and invigorated a serious discussion among psychologists about best practices for data and other related issues. For instance, the Association for Psychological Science recently published a special section of *Perspectives on Psychological Science* on replicability in psychology research, and has scheduled a theme program on good data practices and replicability for their next convention. The biennial meeting of the Society for Music Perception and Cognition is highly-attended by scientists who study music. These attendees come from a diverse range of backgrounds (including psychology), and include individuals at different stages of their careers, some of whom are editors for high-impact journals in the field. Thus, this meeting presents a perfect venue for a discussion of good data practices and replicability in music research. Some of the contributors will present specific studies in which they have failed to replicate previous findings or have collected difficult-to-interpret null results. Others have taken a broader tack, looking at current approaches to replication or null results in our discipline, and the pragmatic tools that have been developed to improve data practices. Our goal is to provide an arena in which shared discussions may lead to improved methodological practice within our field, as well as contributing to the larger conversation taking place in the scientific community.

[3A-4.2] (Quasi) experiments, null results, and finding effects

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Here, I illustrate null results encountered in my own research attempting to replicate, extend, and specify previously demonstrated effects in the music perception literature. Challenges in interpreting effects across many designs and in relating the results of more "naturalistic" studies to laboratory experiments will be discussed. Many effects of linguistic experience (especially native language) on music perception (Alexander et al., 2008; Bradley, 2012; Pfordresher & Brown, 2009), and of musicianship on linguistic performance (Delogu et al., 2006; Lee & Hung, 2008) have been reported in the literature. However, interpreting these results is difficult, because causation cannot safely be inferred from such quasi-experimental designs, and conducting equivalent truly randomized experiments is often difficult or unfeasible (Schellenberg, 2012). Recently, I attempted (a) to extend findings regarding melody perception by native tone language speakers to a second language context, and (b)

to examine findings on lexical tone perception by life-long musicians over a shorter interval. Although these designs are still quasi-experimental, they included more direct interventions than many previous studies. Few significant effects were observed, but interpretation of such null results is difficult given limited sample sizes, smaller effect sizes, limitations of test instruments, and remaining confounds of individual differences. Given these factors, I have thus far regarded these failures to replicate as missing a true effect under more difficult circumstances, but the possibility remains that as confounds in quasi-experimental studies are factored, some effects will prove genuine, and others will require re-evaluation. Avenues underway to address these limitations include increasing the power within the current designs and the development of more fully experimental laboratory-based paradigms.

[3A-4.3] Rhythmic movement seems unlikely to affect the auditory encoding of ambiguous rhythms

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Phillips-Silver and Trainor have argued that moving the body (or having one's body moved) in synchrony with a metrically ambiguous rhythm affects its auditory encoding in a manner consistent with the movement (as long as that movement stimulates the vestibular system). In this work, participants were 'bounced,' in an encoding phase, to either an ambiguous rhythm in time with beats that corresponded to either a duple or triple metrical interpretation. In a test phase, participants listened to pairs of unambiguous rhythms – one accented in a duple fashion and the other accented in a triple fashion – and judged which of the two rhythms best matched what they heard during the encoding phase. Participants overwhelmingly chose the rhythm with an accent pattern that matched how they were bounced – leading the authors to conclude that the bouncing altered the auditory encoding of the rhythm. This talk will discuss the results of a series of experiments where we repeatedly failed to replicate the finding using the same rhythms and general procedure described in Phillips-Silver and Trainor (2007, Experiment 1). Across replication studies, duple and triple bouncing in the encoding phase did not lead to consistent duple and triple choices in the test phase, respectively. Studies investigating why we may have failed to replicate revealed that 1) we are able to replicate the effect when we ask participants to judge how they moved, rather than what they heard, 2) when participants are given the rhythm they heard during the encoding phase in the test phase, they overwhelmingly choose that rhythm over the duple and triple accented versions, and 3) a non-trivial number of participants are able to guess the study hypothesis. Our results will be discussed in the context of the potential role of experimental demand characteristics.

[3A-4.4] Publishing practices in music cognition: Replication studies and null results

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It is good science to replicate experiments and share the results, but publication of replication studies in psychology is few and far between. Using text searches and random sampling, this paper estimated the number of replications studies reported in music cognition's leading journals and conference proceedings. Current practice seems to be geared towards reporting when results concur with previously published work, rather than replicating complete studies. Evaluating null result reporting is much more complicated, confounded both by lack of reporting and exploratory analyses which look to build a more compelling story around unanticipated outcomes. Comparing acknowledgment of null results in abstracts and full papers, this paper tries to estimate the rate at which null results are given due prominence in papers reporting on experiments.

[3A-4.5] How to lie with statistics in the behavioral sciences

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Perhaps you've finished a great experiment, but the results haven't turned out quite as you expected. Or maybe you've ended up with an interaction that seems to complicate your story. You've put in too much time to just stuff it in the file drawer and walk away. You can't afford to add subjects or re-run with another condition. You certainly don't want to make up data! What if your statistics could be just a little… better? In this panel, I'll be discussing different ways to massage your data to get the perfect results. Whether it's strategic omissions of analyses, unnecessary transformations of your data, including (or excluding outliers), or redefining terms, your analyses don't have to tell the whole story. We'll also talk about how to make the most of small effect sizes, and how the right use of graphs can make your effect seem more important. The lawless world of post-hoc tests is another place where you can tell the story you want told. And even if you happen to be an honest soul, more interested in understanding the world than in forcing a particular narrative on it, this discussion will help you navigate the pitfalls associated with different statistical manipulations and to more ably critique manuscripts to understand the story beneath the statistics.

[3B-2.1] An empirical study of historical patterns in musical rhythm: Analysis of German & Italian classical music using the nPVI equation

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This study introduces a new approach for the historical study of musical rhythm based on an empirical measure of rhythm known as the nPVI (normalized pairwise variability index). The nPVI is an equation that measures the degree of durational contrast between successive events in a sequence. While the nPVI is increasingly used for comparative studies of rhythm in music and language, we show that it can also be used for historical research. A historical analysis of musical nPVI values from German/Austrian and Italian instrumental classical music between ~1600-1900 (from *The Dictionary of Musical Themes*) reveals different patterns in the two cultures: German/Austrian music shows a steady increase in nPVI values over this period, while Italian music shows no salient increase. These patterns are discussed in light of the idea (from historical musicology) that the influence of Italian music on German music began to wane in the the 2nd half of the 1700s due to a rise of musical nationalism in Germany. The nPVI data prove to be consistent with this idea, illustrating how nPVI analysis can reveal patterns that enrich and inform historical research.

[3B-2.2] Towards rhythmic syntax of music: Theoretical and empirical investigations

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Musical syntax can be defined as a set of principles governing the hierarchical combination of discrete structural elements into larger units, upon which are superimposed algorithms that determine the way of combination (cf. Patel, 2008; Bickerton, 2009). Theoretical considerations and empirical studies on harmonic aspects of 'musical syntax' have revealed similarities to linguistic syntax in its structural and processing properties (e.g., Patel, 2008; Koelsch, 2012). A syntactic approach however can also be applied to other aspects of music, namely, *rhythm*. *Rhythmic syntax* accounts for the temporal organization of music, in which discrete structural elements such as *beats* are hierarchically combined into larger groups according to rules, or *grammars*, generating *well-formed* metrical and grouping structures. We discuss several components of rhythmic syntax in terms of *headedness* and *discrete infinity* (e. g. Berwick, 2011; Fabb & Halle, 2012; Jackendoff, 2009) and phrasal structure (e. g. Longuet-Higgins, 1976), which are often considered as core properties of linguistic syntax and grammar. Furthermore, theoretical considerations (e. g. Lerdahl & Jackendoff, 1983), evidence from language-music comparisons (e. g. Patel, 2008), studies on child development (e. g. Trainor & Corrigall, 2010), and animal cognition research (e. g. Fitch, 2012; Hasegawa et al., 2011; Honing et al., 2012) are reviewed to explore questions of modularity and human uniqueness of rhythmic syntax. Finally, we relate our findings to cognitive and cultural neuroscience of music (e. g. Seifert et al., 1995; Han et al., 2013; Zatorre et al., 2007) and action syntax (e. g. Jackendoff, 2009; Sammler et al., 2012)

emphasize a strong connection between rhythmic cognition and the capacity of synchronization, and provide some first ideas about the essential role of the sensory-motor interface in the evolution of musical syntax.

[3B-2.3] The effect of language and musical training on rhythm perception

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Here we investigated the effect of musical training and language on beat perception mechanisms. Previous evidence shows that interval-based and beat-based timing mechanisms coexist, but language or musical background may cause some individuals to prioritize one mechanism over the other. Recent evidence suggests that vocal learning may be necessary for beat induction, so exposure to language may be a factor in timing mechanism enlistment. Though quantification of rhythmic differences in language is difficult, many researchers believe there is a qualitative difference in the rhythm of syllable-timed languages such as French and stress-timed languages such as English. 48 participants were categorised by language (French-speaking and English-speaking) and by musicianship (musicians and nonmusicians). Participants completed the ambiguous tempo test, a paradigm that measures the tendency of a person to use either the beat-based timing mechanism or the interval-based timing mechanism to make tempo judgments. $D\chi$ scores, a measure of sensitivity, showed that musicians are better than nonmusicians at discriminating intervals in the subsecond time range. The data also indicate that English speakers are more likely to use a beat-based timing mechanism than French speakers. This finding is the first to demonstrate that exposure to stress-timed or syllable-timed language has a differential effect on enlistment of timing mechanisms when listening to non-linguistic stimuli. These results may support the vocal learning hypothesis of beat perception by strengthening the link between rhythm in language and in music.

[3B-3.1] The Music Therapy assessment tool for advanced Huntington's Disease: Establishing reliability and validity for Music Therapy assessment with a complex neurodegenerative condition

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Huntington's disease (HD) is an autosomal dominant neuro-degenerative disease characterised by motor, cognitive and behavioral disorders. The literature highlights benefits of music therapy (MT) with this population, such as to facilitate meaningful interaction, and emotional expression. However, no robust tools exists to measure responses. The aims of this two-year study were to (a) develop a reliable, validated assessment and clinical monitoring tool for MT with advanced HD and (b) conduct an efficacy study investigating short-term effects. After establishing content validity with feedback from staff focus groups, the MATA HD was designed with 15 measures covering arousal/attention, physical, communication, psychological/social, musical and cognitive responses. MATA HD scores from 19 subjects receiving group MT were compared to comparable items from established tools used with HD, namely the NPIQ, UHDRS and BOSH, indicating that the MATA HD is a reliable measure (i.e., rs of ≥ 0.7) of emotion/mood, communication, cognition, social behavior, aggression/agitation, with arousal and attention correlating similarly to established apathy measures. Analysis revealed a Cronbach's α of 0.825 for 11 MATA HD core measures focused on dimensions of 'engagement,' indicating good internal consistency in relation to its primary focus. The Intraclass Correlation Coefficient (ICC) scores of the inter-rater analysis provided an ICC of 0.66, indicating that whilst some measures were robust, those relating to mood, agitation and movement were weaker. Similarly, the average intra-rater ICC of 0.68 included weaker correlations in mood, eye contact and vocalisation. Discussion of these variations, and steps to strengthen the tools' reliability will be discussed. Furthermore, results from pre-post test analysis of the short-term effects of group MT incorporating a randomised sham design with an independent observer will be presented. Findings will be discussed related to the development of evidence based MT with this population.

[3B-3.2] Creating a clinical conceptual framework for the use of music for emotion regulation with neurodevelopmentally at-risk children

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Emotion regulation is the ability for a person to maintain a comfortable state of arousal by controlling and shifting his or her physiological and emotional experiences and expressions. There are many clinical populations music therapists work with who struggle with emotion regulation, including children who are neurodevelopmentally at-risk. A myriad of factors can contribute to being at-risk—including, but not limited to, poverty, domestic violence, trauma, and sickness—and it can have lifelong cognitive, emotional, and interpersonal effects. One medium long thought to have an impact on emotions and emotion regulation is music. However, there is little in the clinical or theoretical literature on this topic. Furthermore, there is a need in the music therapy literature for more theory-based research to help us better understand the complex interactions between music, our clients, ourselves, and the environment. The purpose of this research was to develop a conceptual framework for emotion regulation and to explore the Therapeutic Function of Music (TFM) as it effects emotion regulation.

Literature used was obtained by searching filtered and unfiltered databases. It was systematically reviewed and information about neurodevelopment, attachment theory, stress, music neuroscience, and music perception and cognition was extracted and synthesized. Results provided an in-depth understanding of emotion regulation and the theory and mechanisms underlying our ability to control and shift our emotional experiences and expressions, as well as created an in-depth understanding of why and how music can affect therapeutic change in children who are neurodevelopmentally at-risk. The implications of this conceptual framework are explored in relation to how they impact clinical music therapy practice and future research.

[3B-4.1] Beyond group differences: Individual difference modulators in experimental designs

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When testing for differences between experimental groups, a null result is potentially interesting but difficult to interpret: a lack of difference between groups does not mean that the groups are the same. This problem may justifiably contribute to investigators' resistance to disseminating null results. One possible approach is to address the possibility of null results at the experimental design stage, by considering the use of independent individual difference measures. Studies that have found no differences between experimental groups sometimes report effects of individual differences, some of which modulate group effects. Individual difference variables can potentially account for null group effects, for example, by explaining sources of intra- and inter-group variability; this may allow investigators to interpret a lack of difference between groups, for instance, if response variability to a manipulation correlates with individual difference scores. In addition, individual differences can potentially reveal group effects that would otherwise be masked by unmeasured variability. I present recent findings from our lab that demonstrate individual difference effects which help both explain null group effects and reveal otherwise hidden group effects. I discuss the merits and drawbacks of this approach, along with how potential modulators could be incorporated into experimental designs; this may involve thinking about cognitive abilities, experience differences, or performance tendencies that may relate to the experimental manipulations. While it may not always be possible to design a study for which any result is interesting and interpretable, attempting to interpret null results before running the study may help ensure that fewer of those results end up in file drawers.

[3B-4.2] The implicit learning of rhythms in a serial reaction-time task: Matching the paradigm to the process

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Implicit learning is learning that occurs unintentionally (Shanks, 2005). One of the predominant methods for examining implicit learning is the serial reaction-time task (SRT), where participants identify sequentially presented stimuli (e.g., auditory spatial locations) as quickly and accurately as possible. Learning is characterized by reaction time decreases over blocks containing the repeating pattern, and increases in blocks containing novel sequences. Some studies that used an SRT to examine the implicit learning of rhythms have not demonstrated rhythm learning in the absence of a correlated ordinal sequence of stimulus identities. However, null results regarding rhythm learning may have arisen due to a lack of sensitivity of the SRT to rhythm learning when the ordinal pattern is unpredictable. The rationale was that, in the SRT, if the upcoming stimulus *identity* is unpredictable then one cannot prepare a response to the stimulus even if the *timing* is predictable. We present data from a study with two different measures of learning (i.e., in an SRT and an immediate recall task) to show an instance where rhythm learning is not demonstrated in the SRT, but is demonstrated in an immediate recall task. Thus, previous null results relating to rhythm learning might be explained by the use of the SRT paradigm and, possibly, other features such as the types of temporal intervals, the type of ordinal pattern, and the modality of the stimuli. We present examples of when rhythm learning has and has not been demonstrated in an SRT; results demonstrate that rhythm learning can be observed in an SRT under certain conditions. The importance of matching the paradigm to the process and the contribution of converging methods and replication are discussed.

[3C-2.1] Can one study the evolution of musicality?

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Given the fact that neither music nor musicality fossilizes, one might wonder, is it possible at all to study the origins of music/ality empirically? While there has been quite some critique on this idea – i.e., the apparent impossibility of studying the evolution of complex cognitive processes such as intelligence (Lewontin, 1998; Bolhuis & Wynne, 2009) – one potential strategy to address this question is to focus on the cognitive traits that could have contributed to the origins of music and musicality (*cf*. Honing & Ploeger, 2012) and see in how far we share these with other animals.

While it is not uncommon to see certain cognitive functions as typically human (such as language), it could well be that there are more species than just humans that have the proper predispositions for music to emerge, species that share with us one or more basic mechanisms that make up musicality. The mere fact that music did not emerge in some species is no evidence that the trait of musicality is absent. In that sense a 'bottom-up perspective' (***cf***. de Waal & Ferrari, 2010) that focuses on the constituent capacities underlying a larger cognitive trait, in our case musicality, is a feasible alternative strategy to follow.

So, instead of studying a complex cognitive trait (such as intelligence) in this approach one explores the basic processes that make up that trait. And in the case at hand: instead of asking which species are musical, the question becomes: how does musicality actually work? What are the necessary ingredients of musicality, and how did these evolve?

[3C-2.2] The evolution of music: Evidence for sexual selection

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Evolutionary adaptations are traits that increase the probability of an organism passing on its genes. Adaptations evolve through two processes: natural selection and sexual selection. Natural selection favors traits that increase the odds of an organism's survival, while sexual selection favors traits that increase the odds of reproduction. Complex behaviors, such as language and music, require the development of neural structures to support these behaviors; the behaviors themselves may provide a window into the quality of the genes that support an individual's neural development. Thus, musical behaviors may provide information that is useful to prospective mates. Four investigations—two correlational and two experimental—were conducted to test the hypothesis that music is a sexually selected behavior in humans, increasing the odds that an individual will reproduce as well as their total number of offspring. Two surveys were administered to male and female participants in the United States. Survey 1 asked participants (N=600) a series of questions about their talents and hobbies (including musical skill), as well as questions about their sexual history. Survey 2 asked participants (N=300) about the talents and hobbies of their parents and number of offspring produced by each parent. There was a significant positive correlation between musical involvement and the number of sexual partners per year reported by our male participants (survey 1), suggesting that musical involvement increases opportunities for reproduction in males. There was also a significant positive correlation between musical skill and the number of offspring produced by males (survey 2). The results of two additional investigations revealed that individuals were perceived as more attractive and intelligent when they were depicted as musicians than when they were depicted as nonmusicians. The results of these four studies are consistent with the theory that music evolved through sexual selection, as originally proposed by Darwin.

[3C-2.3] Do other species show octave generalization?

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Pitch chroma refers to perceiving the quality of a musical note and this quality repeats each time frequency is doubled (an octave in musical terms). Pitch height refers to perceiving differences in frequency on a log-linear scale. Humans use both pitch chroma and pitch height perception: for example, when an adult male and a child sing together, they tend to sing at different frequencies separable in pitch height, but identical in pitch chroma (i.e., they sing the same musical note, also known as octave generalization). However, in practice, it is difficult to assess chroma perception. In addition, although it is known that many other species readily perceive pitch height, it is unclear whether humans are unique in their pitch chroma perception. Our goals here were twofold: 1) to design a task that showed chroma perception in humans and 2) to design the task in such a way that it could be used to test other species to clarify whether chroma perception is uniquely human. Humans and black-capped chickadees (*Poecile atricapillus*), a songbird that relies heavily on auditory information, were trained to respond to a subset of notes (rewarded notes) in octave 4 through trial-and-error with feedback. After completing training, we tested both species with notes in a novel octave, octave 5. While humans responded with the same pattern in octaves 4 and 5, even when we reversed which notes were rewarded in octave 5 compared to octave 4. Chickadees responded with the opposite pattern in the two octaves, and responded more accurately if we introduced opposing contingencies to the training octave, in octave 5. Although adept at pitch height discriminations, chickadees may be chroma blind. We hope to apply this task to additional species to increase our understanding of chroma perception and whether it occurs in other species.

[3C-3.1] Pattern and frame in music perception

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Much of music perception can be described in terms of pattern- and frame-based expectancies. Auditory mechanisms build up expectancies from both 1) direct comparisons of repeated temporal sequences (whose violations may generate mismatch negativities) and 2) statistical comparisons of attributes associated with recent auditory events. Examples of direct temporal comparisons are melodic pattern induction (repeating motifs, phrases, melodies) and rhythmic pattern induction (repeating temporal sequences of events whose timings need not be regular or metrical). Examples of statistical comparisons are tonality induction and metrical induction. In tonality induction a pitch frame of reference is established through recent pitch statistics. In metrical induction, a regular temporal frame is inferred from recent statistics of event timings. Analogously, in speech, rhyme can be seen as a form of timbral pattern induction, and speaker normalization the establishment of statistics-based timbral frames of reference.

Temporal memory comparison mechanisms potentially solve many problems for neurocomputational theories of music perception. Temporal pattern and frame induction processes can be modeled using recurrent timing nets (Cariani, *Neural Networks*, 14: 737-753, 2001; Cariani, *J. New Music Research*, 30: 107-136, 2002). These nets utilize memory mechanisms in the form of conduction delay loops that store time patterns directly in reverberating circuits. In effect, delay loops function as complex oscillators that can build up and regeneratively maintain repeating temporal patterns. The direct storage of time patterns permits circulating patterns to serve as pattern-expectancies that can then be compared with incoming ones. In lieu of strong expectancies induced from pattern repetitions, recent signal statistics in unfacilitated loops create weak expectancies. Although temporal codes for pitch and timbre exist in early auditory stations, and rhythm and duration have robust neural temporal correlates at all levels, the obscure nature of neural coding at the cortical level remains problematic for all theories of musical expectancy.

[3C-3.2] Modulating emotions while listening to film music: A tDCS study

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Emotion and music have long been associated and many studies have linked varying musical structures with different emotions (e.g., Gabrielsson, 2009). Prior neuroimaging studies have indicated a role for several regions in the perception of emotion from music. One common region is the inferior frontal gyrus (IFG), which has been linked to emotion perception in several domains (e.g., Brattico et al., 2011). While useful, brain imaging alone cannot tell us about the causal role of a particular brain region in a given task. For this, non-invasive brain stimulation methods like transcranial direct current stimulation (tDCS) are better suited since it is a non-invasive brain stimulation method that can be used to modulate neural populations beneath targeted brain areas in order to suppress or facilitate cortical excitability under the site of stimulation.

In this study, we will utilize tDCS to modulate cortical activity in the IFG while participants rate their perception of discrete emotions and complete a three-dimensional model (valence, energy, and tension) of film music clips, following Eerola & Vuoskoski (2010). The participants task will be to rate these clips for perceived emotions of happiness, sadness, tenderness, anger, fear or surprise under two conditions: 1) following active tDCS of the inferior frontal gyrus and 2) following sham stimulation of the inferior frontal gyrus (where participants experience the same sensation as active stimulation but no change in cortical excitability occurs). The order of conditions, as well as the two stimuli sets, will be counterbalanced between participants. We expect that ratings will be lower following suppressive tDCS targeted at the IFG relative to sham stimulation.

These findings will provide insights into the neural correlates of the perception of emotion from music, and delineate the functional role of the IFG in this process.

[3C-3.3] Neuromagnetic beta-band oscillation for rhythmic meter processing induced by listening to objectively accented structure

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Music, or rhythmic sound, facilitates synchronized body movements and schema-based, predictive timing perception. When an isochronous unaccented beat is presented, the broadband evoked response from auditory cortex measured by magnetoencephalography (MEG) is different after subjects tap on every second versus every third beat (march or waltz meter) despite the identical sound input in both cases (Fujioka et al., 2010). Furthermore, beta-band (~20Hz) activity in bilateral auditory cortices shows synchronized modulation that predicts the time point of the next beat (Fujioka et al., 2009, 2012). In the present work we examined whether we could induce different metrical perception without induction by tapping. We initially induced a meter by accenting either every second or every third beat and then measured MEG after removing all accents. We analyzed the source activities in the bilateral auditory and sensorimotor cortices using equivalent current dipole estimates and source space projection. We found differential predictive modulation of the overall beta-band activity in these areas that followed whether subjects perceived a march or waltz meter despite the fact that they all heard the same unaccented stimulus. Thus, meter can be induced without movement and is nonetheless encoded in both auditory and motor regions of the brain.

[3C-4.1] The challenges and opportunities of teaching and research at a PUI

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This session focuses on the challenges and rewards of conducting research and teaching courses related to the psychology of music at "primarily undergraduate institutions" (PUIs). These institutions typically have excellent undergraduates, but few or no colleagues with similar interests, no graduate students or post-docs, and may or may not have specialized programs of study in cognitive science or auditory psychology (let alone music perception and cognition). Thus they are quite different environments from the research institutions one experiences in graduate school or in research university. Conveners Andrea Halpern (Bucknell University), Justin London (Carleton College), and Siu-Lan Tan (Kalamazoo College) will lead a discussion that will include: (a) choosing research topics more and less suited for undergraduate environments, (b) funding resources for PUI-based research, (c) teaching and program development at a liberal arts college, and (d) striking a balance between developing an identity as an independent researcher as well as a sought-after collaborator. We will conclude with a discussion on how SMPC can best serve the needs of members at PUIs and how we can attract more colleagues at PUIs to SMPC.

[3D-1.1] Shared action goals in duet music performance

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Duet music performance is a paradigmatic example of joint action, in which two or more people coordinate their actions to achieve a shared goal. Two studies investigated whether people form representations of shared action goals (the combined outcome of their coordinated actions) in addition to representations of individual

action goals (those necessary to achieve each individual's part of the joint action) when they perform duets together. In Study 1, EEG was recorded from expert pianists while they performed duets together. Individual action outcomes (the pitches produced by each pianist) were occasionally altered in a way that either did or did not affect the shared action outcome (the harmony of a chord produced by the two pianists' combined pitches). Event-related potentials elicited by altered pitches indicated that pianists monitored the outcomes of their own and their partners' individual actions in parallel with shared action outcomes. Furthermore, alterations that affected the shared outcome were more salient than those that affected either person's individual action outcomes. In Study 2, novices learned to perform duets with an experienced pianist. Transfer of learning of individual action outcomes (the pitches produced by the novice) and shared action outcomes (the pitches produced by the two performers' combined actions) was measured. Results indicated that novices learned shared rather than individual action outcomes. Together, these findings provide evidence that people represent and monitor shared action outcomes when they coordinate their actions to achieve a shared goal in duet music performance.

[3D-1.2] Effects of dual-task conditions on jazz improvisation

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Examinations of transcribed jazz solos frequently reveal melodic figures that recur with varying frequency, often in the same solo, and sometimes in numerous solos by the same artists. Writers have differed in interpreting the cognitive implications of recurring figures in improvisations. Some regard them as pre-formed structures that serve as the building blocks for lengthier, coherent musical statements; an alternative viewpoint holds that jazz improvisations are generated through learned, rule-based procedures from which recurring sequences occasionally result.

In investigating these theories it is useful to consider how cognitive resources might be allocated during improvisation. The process for generating music must function within the constraints of the cognitive system. Would a process founded on rule-based procedures require a greater degree of conscious engagement than one that draws upon well-learned motor sequences, or vice-versa?

We explore these questions by examining the effects of dual-task conditions on the music produced during jazz improvisations. Experienced jazz pianists will improvise melodic solos based on the 12-bar blues in four experimental conditions. The conditions will vary by key (familiar/unfamiliar) and by task condition (single-/dual-task). In dual-task conditions, participants will improvise while performing an unrelated counting task. MIDI data recorded during these performances will be analyzed using a MATLAB application that detects and indexes recurring patterns.

When testing the protocol in a recent pilot study we found a higher frequency of patterns in solos played in single- versus dual-task conditions, and in the familiar versus unfamiliar key. It would be premature to draw any conclusions from these preliminary results, but we are encouraged that the experimental manipulations produced measurable effects on participants' musical output. Data from a larger group of participants will be collected in the coming months.

[3D-1.3] Expressive trade-offs: Rubato, dynamics, and vibrato in Bach's unaccompanied violin works

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Previous research suggests an inverse relationship between musical complexity and expression. For instance, Temperley (2004) described a "trade-off" between metric complexity and rubato, with performers choosing to play syncopated passages without timing variations. This type of relationship also exists in performances of Bach's unaccompanied violin works. Analytical and perceptual research has shown that Bach's use of implied polyphony

creates some of the complexity and appeal of these pieces (Davis, 2006, 2011). By placing changes of implied voice in metrically weak positions, Bach created melodic accents that produce a sense of syncopation against the isochronous rhythmic patterns. Studies of expressive timing show that expert performers often avoid using rubato during these passages (Davis, 2009). This reflects a trade-off between the complexity created by implied polyphony and the use of timing variations.

The present study compares measurements of dynamics and vibrato with these existing timing profiles. Performances of multiple Bach excerpts were taken from commercial recordings of eight expert violinists. Measurements of dynamics and vibrato were obtained using the Sonic Visualiser software (Cannam, Landone, & Sandler, 2010). The use of all three expressive variables is compared both between and within performers and excerpts. Results confirm that expert violinists are able to simultaneously use various types of expressive nuance in contrasting ways. During passages where implied polyphony creates perceived syncopation, performers avoid disrupting metric clarity by maintaining a consistent tempo and creating emphasis through changes in dynamics or vibrato.

Comparing the use of multiple expressive variables provides insights about the trade-offs that performers make when interpreting complex musical structure. Understanding this relationship supports the relevance of analysis and informs both performing and teaching. Measurements of expert performance can also be compared to judgments of preference in order to identify factors that influence evaluations of quality and creativity.

[3D-1.4] Building a repertoire-appropriate taxonomy of affective expression

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Studies measuring perceived musical affect have examined different groups of affects: "basic" emotions (Ekman 1992), arousal and valence terms (Schubert, 1996), and eclectic lists of emotions (Eerola & Vuoskoski 2011). However, it is difficult to compare results between studies using different terms. Several recent projects have addressed this difficulty by building a general-purpose taxonomy of affective musical terms (Zentner, et al 2008, Schubert 2003). However, these studies assume that the same labels can be effectively used for many repertoires. Recently, Albrecht & Huron (2010) used a bottom-up approach to elicit piece-specific affective labels. This study seeks to expand this work by developing a taxonomy of terms to use for studying Beethoven's piano sonatas. The current report compares lists of affective terms gathered from three participant-generated approaches. In the Pirst study, 50 participants each chose 20 terms deemed most relevant for "early Romantic piano music" from a list of 91 terms taken from three studies (Zentner et al., 2008; Schubert, 2003; Albrecht & Huron, 2010). In the second and third studies, 36 participants listened to 15 excerpts from Beethoven's piano sonatas and chose 5 terms for each excerpt from the same list. Finally, 25 participants provided free-response descriptions of the affect of the same excerpts, subjected to content analysis for derivation of affective terms. The results were compared, to determine how experimental paradigms influence participant-generated affective terms. Finally, results were subjected to cluster analysis, providing a taxonomy of affective terms that are repertoire-specific for the Beethoven piano sonatas. These terms may then be used in future experimental studies on this repertoire.

[3D-2.1] Melodic Intonation Therapy: Is it an effective treatment for non-fluent aphasia?

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In this paper, we review evidence for the efficacy of melodic intonation therapy (MIT) as a treatment for non-fluent aphasia and we discuss the results of an ongoing study. First, we outline the different approaches to MIT that are

currently in use, and their advantages and disadvantages. Second, we describe a protocol that we developed for MIT and the profile of non-fluent aphasic patients who are optimally suited for this approach to treatment. Third, we describe ongoing research in which MIT is combined with non-invasive brain stimulation to treat individuals with non-fluent aphasia following stroke. The study was motivated by previous research in which MIT was combined with transcranial direct current stimulation (tDCS) in order to stimulate the right hemisphere and enhance the benefits of MIT (Vines, Norton & Schlaug, 2011). Our approach complements that study by combining MIT with transcranial magnetic stimulation (TMS). In one series of treatments, we administer MIT after applying intermittent theta bursts (TMS) to the right inferior frontal gyrus (IFG), including the RH homolog of Broca's area. In the other series (a week apart), we administer MIT after sham TMS. Verbal fluency is then assessed. The project is scheduled for completion in May 2013, and will allow us to determine whether the use of TMS has the potential to augment the therapeutic benefits of melodic intonation therapy.

[3D-2.2] Music engagement in Alzheimer's disease

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Despite considerable scholarly interest in characterizing the music cognitive abilities of persons with Alzheimer's disease (AD), the relationship between music cognitive abilities and the musical lives of persons with AD is not clear. One challenge to addressing this question has been a difficulty in measurement: persons living with the cognitive impairment of AD may not be able to accurately complete self-report questionnaires. The Music Responsiveness Scale (MRS) was developed to measure behavioral engagement with music in daily life. It may be completed either by the participant or by an observer who knows the participant well. An initial pool of 35 items was administered to a development sample of 391 respondents who completed the items either in relation to themselves or about another person. Following factor analysis, six factor-weighted subscales were developed, of which five show strong internal consistency. An additional sample of older adults completed the MRS self-report version and had a friend or family member complete the observer version. Convergence between self and observer reports was high. Finally, we will report the results of an ongoing study in which a sample of persons with mild to severe AD completed a collection of music tasks and had a family member complete the observer version of the MRS. MRS scores of the AD group were comparable to those of healthy older adults and were not strongly influenced by overall severity of dementia. The MRS will be a useful tool for understanding individual differences in music engagement either in relation to music cognitive abilities or in the context of music intervention studies.

[3D-2.3] Musical creativity and STEM creativity: A questionnaire and structural imaging study

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The aim of this ongoing study is to determine whether musical experience facilitates creativity and innovation in STEM fields, and, if so, whether any specific type of musical experience (e.g., more or less creative) is optimal. A *Musical Creativity Questionnaire* was designed to assess musical background, including instruments played, quantity of practice, type of study (e.g., more or less creative), and amount of creative achievement. This data (N = 300) is being compared with the results of both advanced brain imaging ($_1$H-MRS, DTI, sMRI) and psychometric measures (intelligence, personality, mathematics, and creative achievement). Results to date (N = 60) indicate positive correlations between musical experience and measures of divergent thinking, openness, fluency, and extroversion. Of particular interest is that experience songwriting correlates with enhanced verbal IQ, whereas experience composing on paper, improvising, and/or writing electronic music correlates with enhanced nonverbal IQ. Numerous brain regions showed increased cortical gray matter associated with musical experience, including: middle frontal gyrus, medial frontal gyrus, orbitofrontal cortex, and superior frontal cortex; lingual gyrus, cuneus, precuneus, and inferior and medial occipital cortices; supramarginal gyrus, Wernicke's area, and fusiform gyrus; posterior cingulate, claustrum, insula, and cerebellum. No brain regions showed decreased cortical gray matter associated with any sort of musical experience. This data makes a compelling case for the positive influence of musical behavior—and hence music education—on the faculties and neurological structures undergirding STEM innovation and creativity.

[3D-2.4] The musician brain: Superior musical perception is supported by high neural 'complexity'

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Musicians provide an excellent model of neuroplasticity (Münte et al., 2002). Structural differences have been observed between the brains of musicians and nonmusicians, (Gaser & Schlaug, 2003) and superior auditory perception in musicians has been associated with specific changes in neural activity (Fujoika et al., 2004; Koelsch et al. 1999). These functional changes have been specific to the instrument of training (Münte et al., 2004), and have correlated with the age at which the musician started training (Pantev et al., 1998), suggesting an experience dependent effect. These studies have eloquently observed specific changes in auditory-evoked brain activity of musicians; however, a mechanism for this neuroplasticity that supports unified musical perception remains to be described.
Human cognition is achieved through activation of dynamic and transient neural networks, and a brain that has a wider range of dynamic network configurations can support a wider range of cognitions and behaviors (McIntosh, 2000). The extent of this range can be indicated by measures of brain signal complexity (Tononi & Edelman, 1998; McIntosh et al., 2008). The measure of brain complexity that we employed in our experiments is called Multiscale Entropy (MSE) (Costa et al., 2002). MSE quantifies the predictability of the brain signal, or any other time series. MSE has previously been shown to change with maturation and aging to correlate with stable behavior (McIntosh et al., 2008), and correlate with cognitive task performance accuracy (Gerrett et al., 2011). Musicians in our study had at least 10 years of formal training, and displayed higher MSE upon initialing perception of musical pieces, compared to nonmusicians. These results suggest that musicians recruit more diverse neural networks during music processing to support a higher level of information processing. This complex brain activity may be ideally suited to capture changes elaborate harmonies, rhythms, and dynamics of music, and may develop through experience to support a more accurate and wider range of musical behaviors.

[3D-3.1] RAVDESS: The Ryerson Audio-Visual Database of Emotional Speech and Song

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Research on the perception and production of emotional expressions in face and voice has blossomed over the last decade. Interest from researchers in psychology, clinical therapies, neurosciences, computing and vision sciences, and artificial intelligence, has generated a pressing need for a set of high quality, validated presentations of facial and vocal emotion. With this in mind we created the Ryerson Audio-Visual Database of Emotional Speech and Song. The RAVDESS consists of 24 professional actors, speaking and singing matched statements in North American English, with a large range of different emotions, each with two intensities. The singing corpus is comprised of portrayals in neutral, calm, happy, sad, angry, and fearful emotions, while the speech corpus contains the same expressions in addition to surprise and disgust. The RAVDESS contains over 7000 files in full audio-video (720p H.264), video-only, and audio-only formats. The database is released freely under a Creative Commons license, and is accompanied by psychometric evaluations of emotional accuracy, emotional intensity, and genuineness of expression. To assist researchers interested in modeling and analysis, the database is also packaged with full vocal acoustic and facial motion analyses, Praat and Matlab scripts, and full statistical data and analyses. Pilot evaluations of a core set of actors indicated that overall accuracy of expressions was 78.9% across all emotion categories, intensities, modalities, and production domains (speech and song).

[3D-3.2] The effect of visual stimuli on the perception of emotion in speech and music

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A number of correlates between speech and music have been examined in recent years. For example, both raised F0 and raised musical pitch are commonly associated with happiness, while lowered F0 and lowered musical pitch are more likely to be associated with sadness (Bolinger, 1964; Morton, 1977; Juslin and Laukka, 2003). Additionally, the theory of "sound-size symbolism" (as discussed in Hinton, Nichols, and Ohala, 1994) explores the relationship between pitch height and the perceived size of an object. Recent work by Shanahan and Nisula (*in preparation*) has used both a reaction time experiment and an implicit association task to quantify the correlations between the perception of pitch height and visual stimuli.

The current study examines the effect of visual stimulus size on the perception of emotion in the spoken voice. Participants were presented with recordings of speakers reading emotionally neutral sentences in a specified affect: sad, sleepy, aggressive, friendly, or neutral. The recordings were accompanied by a visual stimulus of a random size. A second study examines the role of the size of visual stimuli on the perception of nominally neutral melodic phrases. Participants were presented with visual stimuli of a random size, along with melodic phrases ranging between 2 and 4 measures, that were deemed by participants to be of neutral affect. Although these studies are currently collecting data, it is hypothesized that participants would be more likely to judge both emotionally neutral sentences and musical phrases as aggressive when presented with a larger visual stimulus. Conversely, they would be more likely to perceive a neutral sentence or musical phrase as friendly when given a smaller visual stimulus. By examining the role of size on the perception of emotion in both speech and melody, this study explores connections to work previously carried out by ethologists on animal signaling.

[3D-3.3] Is facial mimicry in response to emotional song automatic?

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When we communicate with others vocally, our faces are continuously moving and expressing linguistic, musical, and affective information (Munhall et al., 2004; Thompson, Russo & Livingstone, 2010). Facial electromyography of observers has been used to measure facial movements, and subtle mirroring of visual aspects of emotional song has been found (Livingstone, Thompson & Russo, 2009; Chan, Livingstone & Russo, in press). According to the facial feedback hypothesis, when an individual produces an emotional facial expression (i.e., a smile), he/she will experience the associated emotion (i.e., happiness) as a result. Thus, if individuals observe and unconsciously mimic expressions of singers, they may have rapid access to the singer's emotional intent. Facial mimicry is thought to be an automatic response for non-music stimuli, but it is unclear whether this is also the case for emotional song. To build on previous studies and test automaticity, we presented participants with video clips of emotional song, and instructed them to inhibit their facial movements. If mimicry was observed despite this instruction, it could serve as support of its automaticity. Facial electromyography was used to measure the degree of mimicry of muscle activity in the corrugator supercilii muscle (associated with sad emotion) and the zygomaticus major muscle (associated with happy emotion). Results showed more corrugator muscle activity for sad vs. happy trials, and more zygomaticus activity for happy vs. sad trials. These results suggest that facial mimicry may be an automatic process, and future research will continue to explore and clarify additional questions in this topic area.

[3D-4.1] Audio-visuo-spatial mappings in real-time: How musical training shapes gestural cross-modal correspondences

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Cross-modal correspondences of auditory stimuli have been studied extensively using paradigms such as speeded classification and forced-choice matching tasks. While pitch–height and loudness–size associations are commonly reported, there is an increasing body of literature suggesting that visuo-spatial mappings may be varied and asymmetrical. To further examine how pitch, loudness and elapsed time are mapped spatially, and to investigate the influence of musical training on cross-modal correspondences, we introduce a new paradigm measuring participants' gestural cross-modal responses to sound in real-time. Thirty-two musically trained and thirty-two musically untrained participants were asked to represent gesturally twenty-one pure tones, each eight seconds long and systematically varied in pitch, loudness, and tempo. Participants' right-hand movements were captured using low-cost technology (Microsoft Kinect) and bespoke software. In the second of two conditions, participants' movements additionally created a real-time visualization on a large screen in front of them, consisting of a black disk on a white background, responding to movements in all three spatial directions. By moving towards (away from) the screen the size of the disk increased (decreased). Using mixed-design ANOVAs to compare participants' averaged non-parametrical correlations between sound characteristics (time, pitch, loudness) and all three spatial axes, it was revealed that elapsed time was most strongly associated with the x-axis (0.485), pitch with the y-axis (0.654), and loudness with both y-axis (0.310) and z-axis (0.152). Moreover, participants tended to switch from y-axis (non-visual condition) to z-axis (visual condition) when representing loudness, and musically trained participants showed higher correlation coefficients for pitch–height and loudness–height mappings but not for elapsed time. These results provide evidence that pitch–height mappings are much more stable than mappings of other musical parameters such as loudness, and suggest that even if pitch–height mappings prove innate, audio-visual correspondences are readily enhanced by cultural factors such as training.

[3D-4.2] Hearing with your eyes: Two studies exploring extra-musical factors on perception–body movement and subtitles

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We asked whether two types of extra-musical factors (body movement and subtitles) would have an effect on listeners' perceptions of musicality and expressivity in music performances. The purpose of the first study was to determine what effect body movement would have on listeners' (N = 90) perceptions of a professional chamber ensemble performance. Using a Likert-type scale, listeners were asked to rate each of three performances on the basis of perceived appropriateness of style and perceived ensemble expressivity. While the video portion of the stimulus changed to reflect each of three movement conditions: (1) deadpan – no extraneous movement, (2) head/face movement only, (3) full body movement, the audio portion of the stimulus remained the same. Results indicated that increased movement in performance corresponded to higher style and expressivity ratings. Differences were also found on the basis of major, although the effect size was small (η_p^2 = .06), and presentation order. The purpose of the second study was to determine what effect subtitles would have on listeners' perceptions of expressivity in an operatic performance. An excerpt from a live production of Puccini's *La Bohème* was used as the music stimulus. Participants (N = 103) were randomly assigned to one of three listening conditions: audio only, audio + video, audio + video with subtitles. Continuous data were collected via the Continuous Response Digital Interface, and summative data were collected via a post hoc questionnaire. Results revealed significant differences in listeners' continuous data among all three groups, with the audio condition evidencing the highest response magnitude, and the subtitles group receiving the lowest response magnitude. No significant differences were found among the groups' summative ratings of expressivity. Implications of findings and directions for future research will be discussed.

[3D-4.3] Exploring the characteristics of timbre-colour synaesthesia

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Synaesthesia is a rare perceptual phenomenon in which stimuli in one sensory modality induce vivid sensations in a second unstimulated modality. This project is focused on studying a specific type of synaesthesia, that is, timbre-colour synaesthesia, which has not been examined as much as other types, e.g., pitch-colour synaesthesia (Ward, Huckstep & Tsakanikos, 2006). In particular, we aim to characterize this form of synaesthesia and investigate whether it shares characteristics with other types of synaesthesia, especially consistency over time and automaticity of mapping between the stimulated and unstimulated modalities.

Firstly, we will test whether the synesthetic colours elicited by timbre are more consistent over time, in synesthetes' reporting of specific colours, relative to a non-synesthetic control group. The sound stimuli will be taken from the McGill University Master Samples (MUMS) and will comprise real sounds of musical instruments of all families, i.e., brass, string, woodwind and -only tuned- percussion instruments, matched for duration, loudness and pitch. Consistency of colour selection will be retested twice, namely, within the same day and after one month.

Additionally, since the occurrence of the synesthetic experiences is automatic and not easily suppressed as it is not under the synesthetes' conscious control (Mills et al., 1999, Ward & Mattingley, 2006), participants with timbre-colour synaesthesia will take an auditory-visual Stroop-type test in order to investigate the automaticity of color perception following the auditory timbral stimulation. Participants will be required to name visually presented colour patches that will be paired with auditory stimuli that are either congruent or incongruent with respect to their reported timbre – colour association. We predict that only synaesthetes, and not non-synaesthetic controls will demonstrate reaction time differences as a function of congruence.

[3D-4.4] Shared traits in tone-color synesthesia and absolute pitch

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Recent studies have demonstrated that individuals with absolute pitch (AP) or synesthesia both exhibit hyperconnectivity of the sensory pathways in the brain. Behaviorally, synesthetes differ in their perception of stimuli where they experience their synesthesia, while AP possessors show above average perceptual abilities. Given the existence of hyperconnectivity in each condition, one can hypothesize that individuals with AP may demonstrate a higher than expected incidence of tone-based synesthetic experiences; similarly, that tone-color synesthetes (chromesthetes) may possess a higher than expected degree of AP ability due to how they perceive music differently from everyone else. Preliminary research has shown that such comorbidity can occur and in some cases, synesthetes can name pitches purely by remembering what colors they elicit.

Given these facts, we designed our study to examine the following hypotheses:

1.) People with AP show an above-average prevalence of synesthesia, particularly tone-color synesthesia. We are testing this hypothesis for the first time on a large sample using an international internet survey that includes tests modeled after Eagleman, Kagan, Nelson, Sagaram, and Sarma's (2007) synesthesia battery and Bermudez and Zatorre's (2009c) AP test.
2.) Chromesthetes will show evidence of heightened pitch perception and memory. We are testing this hypothesis using a behavioral study comparing chromesthetes, non-pitch synesthetes, and matched controls. The study comprises synesthesia and AP assessments (as above), a psychoacoustic pitch modulation discrimination task and a pitch memory task.

This study is presently in data collection phases. Our results will add valuable data on the prevalence rates of both these conditions and aid in understanding the co-morbid behavioral manifestations of AP and synaesthesia.

Poster Abstracts

[3-01] The relation between accuracy of production of the major triad and Mandarin speech tones in native-speakers of English or Mandarin

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To investigate the role of specific language and cultural experience on singing skills, we studied the accuracy with which 16 native Mandarin- and 16 native-English-speaking participants reproduced a spoken Mandarin phrase and a vocalized major triad. The Mandarin phrase contained 4 Mandarin tones (syllable intonations) --flat (high), up (rising), down-up (low or dipping), and down (falling). The relation between language and singing performance measures was also analyzed. Participants carried out the AIRS Test Battery of Singing Skills (Cohen et al., 2009) on-line version (B-Y Pan & Cohen, 2012). Subsequently, the relevant segments of the battery were submitted to analysis. Visually depicted pitch contours (derived by Praat) for the 4 Mandarin syllables (tones) from each participant were analyzed on a 5-point accuracy scale by 5 raters who compared each visually represented syllable to a visual model. High inter-rater reliability (Cronbach's alpha = .94) permitted data averaging. Two Mandarin speakers also rated the accuracy of audio intonations. Mean visual and audio ratings were correlated ($r = .76$, $p < .001$). As expected, native-Chinese participants outperformed native-English speakers on Mandarin tones. Two experienced musicians rated the aural major triads on a 5-point scale. Error for the 3 sung intervals comprising the triad was also computed via Praat. Total error was negatively correlated with mean aural ratings ($r = -.79$, $p < .001$). Mean rating of the major triad (4.05, SD .995) did not differ significantly for the language groups and was independent of Mandarin tone accuracy. The conclusion that non-overlapping processes serve vocal production of speech tones and major triads finds additional support in analysis of more complex triads (minor, augmented, diminished) which likewise revealed no relation. However, music training variability, uncontrolled in this study, may have masked the relationship between triad and Mandarin tone accuracy, at least for native-English participants.

[3-02] Chord discrimination in the Zebra Finch (Taeniopygia guttata), Budgerigar (Melopsittacus undulatus), and Human (Homo sapiens)

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Previous research has demonstrated chord discrimination abilities among European starlings (*Sturnus vulgaris*; Hulse, Bernard, & Braaten, 1995), pigeons (*Columba livia*; Brooks & Cook, 2010), and black-capped chickadees (*Poecile atricapillus*; Hoeschele, Cook, Guillette, Brooks, & Sturdy, 2012). The latter two of these studies tested human chord discrimination as well and found a comparable pattern of results. Avian chord discrimination in these studies was found both in songbirds and non-vocal learners. However, these studies did not address possible subtle difference in chord discrimination among open and closed-ended vocal learning birds. Given recent data suggesting that vocal learning status influences rhythmic entrainment (Honing, Merchant, Háden, Prado, & Bartolo, 2012), we considered this variable to be potentially important for other aspects of music processing. The present research addresses this issue by modifying the procedure used in past studies while testing two new species: zebra finches and budgerigars. Using a two-alternative forced-choice task we tested discrimination of the same stimuli used in Brooks and Cook (2010) and Hoeschele et al. (2012) across these bird species as well as in humans. Two sets of stimuli were used, one set was based on manipulations of a C-major chord (root position) and the other was based on manipulations of a D-major chord (also root position). The major chords functioned as standard stimuli. Comparison stimuli were created by systematically varying the 3rd and 5th positions of the chords up or down by one semitone. The results show differences in chord discrimination performance across bird species, which suggests vocal learning strategies may contribute to perceptual sensitivity of harmonically complex stimuli.

[3-03] The prevalence of music training in a university population

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The benefits of music training have the subject of many studies and stories lately, in part because of the implications for educational policy. Music training has been shown to be associated with improvements in several basic cognitive measurements, as well as reading and language skills; these changes are also reflected in brain structure. However, there has been no attempt to date to assess the general level of music background in the student population. Here, we surveyed over 1000 students to characterize their music training and self-assessed abilities. We found that over 90% of students had received some form of music instruction, including private lessons, school-based lessons, and self-teaching, and many had trained on an instrument for several years. Participants tended to begin training at an early age, especially those who had taken private lessons. Our participants also reported that they enjoyed music and perceived themselves to have many basic musical skills, with the notable exception of singing. These findings show that even those often categorized as nonmusicians may have had some musical training, and point to the importance of careful screening for different types of music training in future studies. These suggest that musicianship should be treated as a continuous, rather than strictly categorical variable.

[3-04] Infants' preferential attention to sung and spoken stimuli in audio and audiovisual context

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Caregivers and early-childhood teachers all over the world use singing and speech to elicit and maintain infants' attention. Infants' preferential attention to speech over nonspeech sounds is well document. However, research comparing infants' preferential attention to music and speech has shown no preference for one or the other one. The purpose of this investigation was to study 11-month olds infants' preferential attention to the spoken and sung renditions of an unfamiliar song presented in audio and audiovisual contexts.

Twelve infants participated in each of three experiments. One was based on the audio recording of a young woman singing and reciting a folk song, another one on the audiovisual recording of both versions of the tune, and the third, on the visual (no audio) presentation of the videos. Infants' attention to the spoken and sung stimuli was compared through an infant-controlled preference procedure.

The findings challenge infants' well-documented bias for speech over non-speech sounds but support those of a previous study that music may be more effective than speech in capturing and maintaining infants' attention when presented in an audiovisual context. In the audio condition, music was as effective as speech in eliciting infants' attention and in the audiovisual condition, infants showed a clear preference for the musical rendition of the stimulus. Implications for music education are discussed.

[3-05] Understanding the child singing in Brazilian Maracatu

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Popular culture manifestations provide several opportunities of contact with Brazilian Art forms. In most of these popular manifestations the act of singing is involved. This ongoing study aims to understand characteristics of children's singing in different groups of *Maracatu de baque virado*.

Maracatu de baque virado is a folkloric manifestation that happens during Carnival. The musical part of this manifestation is basically played by percussion instruments, such as the *alfaias* (a type of drum played with sticks) and *abês* (a kind of rattle). The song, performed by the master (a sort of conductor), serves as a guide to all musical arrangements. Most members of the *maracatu* are adult, but some children are involved in playing and singing. For the present study, data collection was conducted with four girls age 5-11 from the shantytown of Pina in Recife, a large

capital city in the Brazilian Northeast. Participants were interviewed and also sang while playing the *abê*. During the interviews, carried out in their own homes, 13 songs were recorded on audio and vídeo. In this paper. we present the musical data collected, which was analyzed following two main point. Firstly, in relationship to Brazilian studies about learning music in popular culture along with the integration of body gestures and music (Prass, 1998; Arroyo, 1998; Queiroz, 2005, Braga, 2005; Náder, 2006; Abib, 2006; Gramani, 2009). Secondly, we discuss musical development and cognitive processes in music based on a musical community that has been understudied.

[3-06] A case study of the processes involved in the musical learning the Brazilian rabeca

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This paper presents an investigation about learning rabeca (type of fiddler) in fandango caiçara, a folkloric manifestation of Brazil. A case study was conducted based on the experience and comments collected from rabequistas (instrumentalist who plays rabeca) from the same family who lives in Ariri community, coast of São Paulo State, Brazil.

Data collection included participant observation, field notes, interviews and instrumental lessons with three rabequistas, named Zé, Arnaldo and Laerte Pereira. Musical perception accuracy is a fundamental ability once the rabeca has no indication of the correct position of the fingers on the strings for tuning. In this paper we present some reflections about the importance of imitation, musical memory and enculturation in processes of musical perception through learning rabeca. Findings are discussing with ethnomusicology studies (Prass, 1998, 1999; Arroyo, 1998; Queiroz, 2005; Braga, 2005; Nader, 2006; Abib, 2006) and musical cognition (Sloboda, 2008; Galvão, 2006; Santiago, 2006; Alencar; Fleitch, 2003).

[3-07] Music preferences and personality traits: Examining a four-category model of music genre preferences and its correlates with personality traits

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A growing body of work from multiple research domains suggests that personality traits influence music preferences and usage. Music preferences commonly evaluated are those for generic music genres (such as rock, pop, jazz, classical, techno, latin, funk, etc.). The extensive array of possible genres, subgenres, differing definitions, and developing genres, makes the task of linking genres to personality traits potentially complex, cumbersome and difficult to utilise. Rentfrow and Gosling (2003) broadly suggest that music genres can potentially be classed into just four categories (labeled: reflective and complex, intense and rebellious, upbeat and conventional, and energetic and rhythmic) and, furthermore, that preference patterns for these music categories may be linked to different personality traits. We aimed to test this theory, as well as their Short Test of Musical Preferences (STOMP) measure. Rather than using different pieces of music to represent each category as is common in this type of research, a novel approach was used in generating the music stimuli. Four pieces of music (two original, two commercially published) were recomposed to meet the broad criteria of the genres grouped to comprise each of the four categories (i.e., four different renditions of each piece, yielding 16 pieces in total). Participants were asked to categorise each recomposed piece (presented randomly), select the most appropriate generic music genre label, and complete the STOMP and a personality measure. Preliminary analyses suggest that the parameters used to recompose the music did not produce pieces that participants were equally able to correctly identify as belonging to the intended categories. However, generic genre labeling was generally as expected, and further, was consistent with the intended grouping of genres forming the categories. This may indicate an issue solely with the naming of the categories, rather than with the representativeness of the recomposed pieces or with how the genres are grouped to form the categories. Correlations between the categories themselves, people's preferences, and personality traits are also discussed. Overall, initial findings support that a four-category model may be an appropriate method to approach examining the relationship between music preferences and personality type. Further, that music preferences may be indicative of personality type and, conversely, that personality type might offer an insight into likely music preferences. Such insights, in turn, will have useful applications in research, clinical, and commercial settings.

[3-08] Child's play: Pitch height as a cue for happiness and sadness in music for children

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In general, modality (major/minor) serves as a strong cue for conveying happiness or sadness in music. However, research on this topic generally uses music and experiments intended for adults, rather than for child listeners. Previous work has shown that children do not weight mode to the same degree as adults. Instead, they heavily rely on low-level acoustic cues, such as pitch height, when assessing emotional tenor (Dalla Bella et al., 2001). This raises the question of whether music in major and minor keys for children follows the same patterns as similar music for adults. Here, we used Schumann's "*Album for the Young*" (Op. 68) to compare large-scale differences in the use of pitch height in major and minor key music intended for children. To create a balanced corpus, we selected 12 pairs of pieces matched in each chroma (i.e., C Major/c minor, etc.). Then we quantified pitch height by assigning a number to each note and weighting this value according to note duration in order to yield the average pitch height for each of the first eight measures.

Consistent with previous results (Poon & Schutz, 2011), major key pieces exhibit a higher average pitch height than minor. This suggests that although young children have not yet learned to associate major keys with happiness and minor keys with sadness, children's music still follows similar patterns with respect to the use of pitch height. This is consistent with previous research demonstrating that when attempting to convey happiness vs. sadness, even young children sing at higher pitch heights (Adachi & Trehub, 1998). We will discuss these results in the context of the debate over whether or not associations between modality and emotion are innate, or acquired through exposure and enculturation.

[3-09] Mix 'n' Match: Validating a new musical working memory task

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There is growing literature investigating the impact musical training has on executive function, including working memory. Studies demonstrate enhanced working memory abilities in musicians compared to non-musicians on verbal, auditory and visual memory measures. However, working memory is typically investigated using artificial tasks from the cognitive psychology literature, and little is known about the mechanisms behind musical training itself that may enhance working memory in musicians. The objective of this study was to investigate the relationship between performance on lab-based working memory tasks and a task that mimics real-world listening skills developed as part of musical training. Subjects included musician and non-musician university students, matched on age and socio-economic status. Subjects were administered a battery of tasks, one of which was a newly developed musical task measuring working memory. The musical task provided subjects with practice listening to and identifying three melodies played on high or low pitched instruments. As the task progressed, it became more challenging since it required subjects to keep in mind two melodies playing simultaneously while also attending to a new melody that replaced only one of the previously heard melodies. Such a task could pose difficulty for non-musicians, as they do not have the domain specific listening skills necessary to perform well on the task. However, it may be that general working memory skills, as demonstrated using lab-based tasks, generalize to produce better performance on this musical task. Our results show that musicians significantly outperformed non-musicians on most Mix 'n' Match questions. Non-musicians showed learning during the Mix 'n' Match task. Better performance on lab measures of working memory including digit span and n-back correlated with better Mix 'n' Match performance for non-musicians, suggesting a domain general working memory ability tapped by this task.

[3-10] Seniors' autobiographical memory of musical experiences: Insights and new questions from an interview study

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Autobiographical memory is recollected from an individual's life and based on a combination of episodic and semantic memories (Conway & Pleydell-Pearce, 2000; Snyder, 2009). As one's autobiographical memory is related to self-perception, it may provide valuable information of personal identity (Conway & Holmes, 2004) and psychological well-being (Singer & Salovey, 1993). While autobiographical memory has been extensively considered by psychologists and sociologists alike (Conway & Holmes, 2004), few studies in music education have addressed autobiographical memory in seniors using qualitative approaches. This study involved documenting eight Angelino seniors (4 men, 4 women from different ethnic backgrounds, aged 69-92) and their memories of songs and musical experiences, through in-depth interviews and observations. A wide variety of songs and musical practices emerged in the interviews, along with different abilities for recalling music-related memories. While all elderly participants were highly engaged in the invitation to share their stories, some seniors reported being challenged by the process of recollecting memories. This led to the question of potential associations between personal meanings and the ability to recall music-related experiences in advanced age. Considering that one's sense of self is critical in both the encoding and retrieval of autobiographical memories (Conway & Pleydell-Pearce, 2000), it is possible that participants who easily recalled their music-related memories perceived music as having a highly meaningful place throughout their lives. Inversely, seniors who experienced challenges in their musical memories may have seen music as less significant in their lives. A full description and analysis of data will be presented at the conference, along with implications for future research.

[3-11] Enhancing young listeners' music meaning constructions

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As music is a temporal art form, it is difficult for a child to listen to and to retain several musical ideas, especially in new music, as "when the music finishes, children have experienced so much that, while they may be able to discuss some most recent musical idea, it may be difficult for them to return to earlier musical images" (Blair, 2007: 10).

This research started with the creation of a new music violin piece, which was written for children. A video was also created. The objective was to understand if the contemporary music language would better communicate with the younger audience when presented with images, and how these imagenings could occur (Walton, 1997).

Two performances of the piece were held one month apart: in the first performance the piece was played without the video, and in the second it was presented with the video. Four questions were asked to 16 children after each performance, in order to identify which musical aspects children valorised the most while listening to the piece.

This case study explored the relationships between the process of the young listeners' perception and the process of constructing musical meaning. It also analysed the role of metaphor in the way children perceived the ce. Interviews made after the second performance indicate that most children recalled vividly musical aspects that they had heard in the piece. It was also observed that the young listeners seemed to find it easier to follow the music in connection with the image, as it helped them to shape meaning, generating individual musical understanding. The musical material, together with the image, ensures that even the less experienced listener will almost immediate comprehend the music language, consolidating a genuine invitation to a more independent, enjoyable and meaningful understanding.

[3-12] The role of temporal structure in tonal learning

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In two experiments we investigated potential mechanisms through which listeners could acquire tonal knowledge. During a familiarization phase, we exposed non-musician adult listeners to an unfamiliar two-minute long (whole-tone scale) sequence. In a subsequent test phase we examined listeners' learning using either a grammaticality or probe tone judgment. For the grammaticality judgment, participants indicated which of two short test sequences was most similar to the familiarization sequence. For the probe tone judgment, participants provided fit ratings for probe tones that followed short context sequences. Context sequences were either congruent or incongruent with statistical regularities in the familiarization sequence. We reasoned that if participants were learning the statistical structure during the familiarization phase, then sensitivity to the statistical structure of the context sequences should be stronger when the familiarization stimulus was congruent with the context sequences. Experiment 1 examined learning from pitch frequency-of-occurrence. Grammaticality judgments were significantly above chance (Exp. 1a), and frequent pitches received higher probe tone ratings (Exp. 1b). Probe tone ratings were strongly influenced by pitch frequency-of-occurrence in the context sequences and the effect was stronger when the familiarization stimulus was congruent with the test sequences. In Experiment 2 we presented a familiarization sequence containing one sub-set of pitches that occurred more frequently on strong than on weak metrical positions and another sub-set that did the opposite, with overall frequency-of-occurrence balanced across sub-sets. Grammaticality judgments were again above chance (Exp. 2a) and probe tone ratings were higher for pitches occurring on strong metrical positions (Exp. 2b). This effect was stronger when the familiarization and context sequences were congruent. These findings suggest that participants were learning the statistical structure during the familiarization and that this learning influenced their perception of tonal stability during the context sequences.

[3-13] Implicit knowledge of rock harmony

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Music-theoretical accounts (e.g., Stephenson, 2002) and a recent statistical corpus analysis (de Clercq &Temperley, 2011) indicate that Rock music (construed broadly to mean most recent popular music) utilizes all the chords of Common Practice, plus many that violate Common Practice. Previously, we reported evidence that untrained listeners possess some explicit knowledge of Rock harmony, as measured by surprise and liking ratings for two-chord sequences (Craton et al., SMPC, 2011; not presented due to illness). Here we extend this work in two experiments employing implicit measures.

We used the harmonic priming paradigm (Bigand & Poulin-Charronat, 2006). The participant's task was to determine as quickly and accurately as possible which of two timbres (gui tar or trumpet) characterized a *target* chord. On each trial, the target was preceded by a harmonic prime context (a series of chords played using a piano timbre) that made the target chord relatively likely or unlikely.

Listeners heard 31 (major, minor, or dominant 7) target chords played after a brief musical context (Exp 1: major scale or major pentatonic scale + tonic major triad; Exp 2: minor pentatonic or mixolydian scale + tonic major triad) or a non-musical context (white noise + silence). The manipulation of greatest interest was the harmonic relatedness of the prime and target chords: 1) *traditional diatonic* target chords were those that occur in both Common Practice and Rock music; 2) *rock-only diatonic* target chords are unexpected in Common Practice music but expected in Rock; and 3) *nondiatonic* chords lying outside either harmonic system.

Data collection for both experiments is complete. To the extent that listeners possess implicit harmonic expectations based on Rock harmony, we expect reaction times in both the traditional diatonic and the rock-only diatonic conditions to be shorter than those in the nondiatonic condition. Analyses of these data are ongoing.

[3-14] Using false feedback to test the confidence account of amusia

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Congenital amusia has long been considered a deficit of fine-grained pitch processing. However, based on recent behavioral, functional neuroimaging, and neuroanatomical data, some theorists have suggested that the cognitive mechanism underlying amusia might be a deficit of confidence. More specifically, an abnormal frontotemporal pathway in amusic patients seems to prevent normally-processed pitch information from reaching awareness, leading to a deficit in confidence in tasks requiring access to that pitch information. In order to assess whether a deficit in confidence might underlie amusia, we have attempted to elicit amusic behavior in normal controls by manipulating their confidence using false feedback. Non-amusic participants performed a task in which they were required to detect out-of-key notes in monophonic melodies played with a piano or acoustic guitar timbre. Participant responses were collected using a four-point confidence scale. During the first 80 trials of the experiment, participants received no feedback, in order to establish baseline task performance. During the last 80 trials of the experiment, participants received false (random) performance feedback aimed at reducing confidence in their tonal perception. Although there was a trend towards decreased confidence during false feedback blocks for some participants, performance accuracy was unaffected by false feedback. In other words, reducing participants' confidence does not lead to "amusic" behavior in normal controls. These results demonstrate that normal tonal perception is a robust phenomenon, and support the idea that the amusic disorder is more than simply a failure of confidence.

[3-15] Are minimalist and post-minimalist music more appealing than modernist music?

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Both minimalist and post-minimalist music have often been characterized as being more accessible than modernist music (Rockwell, 1983; Bernard, 1993; Gann, 1998; Potter, 2000). This paper presents empirical evidence for these claims. Thirty-three college students of differing musical backgrounds were asked to rate their enjoyment of twenty-four modernist, minimalist, and post-minimalist pieces of music. As expected, participants of this study tended to prefer minimalist and post-minimalist music over modernist music. The highest enjoyment was reported for post-minimalist film music and post-minimalist lyrical instrumental pieces, though lower enjoyment was reported for pieces from the minimalist core repertoire, which may perhaps be related to the higher amount of direct repetition in this music and participants' lack of familiarity with minimalist processes. There was one consistent exception in the findings, however. Whereas the predominance of diatonic harmony, a clear pulse and simple rhythms, as well as strong connections to traditional musical styles (rock, classical, plainchant, etc.) normally made post-minimalist music more appealing than typical modernist compositions, the presence of prominent vocal parts—either sung or spoken—in five post-minimalist pieces had a polarizing effect on participants responses. For instance, while most participants reported liking Pärt's "De Profundis" less than many of the modernist pieces, the few participants who did like it not only reported enjoying "De Profundis" more than all the modernist pieces, but also more than most other post-minimalist pieces. These same participants reported enjoying plainchant and renaissance sacred music, unlike the rest of the participants, which suggests that a listener's familiarity with certain vocal styles, or lack thereof, can have a disproportionate effect on their enjoyment of unfamiliar musical styles such as minimalism and post-minimalism.

[3-16] Role of saliency of pitch deviations in a melodic context: A mismatch negativity study

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Both a mistuned and an out-of-key note in a melody can elicit a mismatch negativity (MMN), an early negative component of the electric activity measured from the brain scalp. The MMN can be observed while the listener is not attending the melodies, suggesting that these melodic incongruities can be processed automatically. However, melodic incongruities can be salient enough to capture the participant's attention. The aim of our study was to test if a MMN can still be observed when the participant is performing a concurrent auditory task. Participants were requested to detect a click, which intensity was individually adjusted so that it could be detected 75% of the times. In the subsequent control task, the same participants had to detect the melodic incongruities. Clicks were still present but had to be ignored. Fifteen young adults, having little musical training, took part in the study. In both tasks, a robust MMN response to the mistuned and out-of-key notes was obtained, the MMN being larger for the out-of-tune pitches. Furthermore, the presence of an out-of-tune pitch interfered with the detection of the click. These results confirm that melodic incongruities can be salient enough to capture attention and contribute to the size of the MMN. However, this may not be the case for the out-of-key notes which may go unnoticed, but still be recorded by the brain.

[3-17] Surface and structural effects of pitch and time on melodic similarity

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The identity of a given melody resides in its sequence of pitches and durations, both of which exhibit surface as well as structural information. For the purposes of this research, pitch contour served as pitch surface information, and tonality as pitch structure; in the temporal dimension, surface information was the serial duration ratios of adjacent notes (temporal contour), and metre comprised the structural information. Manipulating systematically all four of these forms of information enabled measuring their effect on perceived melodic similarity. Using 48 typical yet unfamiliar Western melodies, there were four levels of pitch structure: the original pitch sequence, contour-violated, tonality-violated, and both-contour-tonality-violated. Similarly, there were four levels of temporal structure: the original duration sequence, ratio-violated, metre-violated, and both-ratio-metre-violated. Combining all 4 levels of both dimensions gave 16 conditions. In Experiment 1, participants (N=34, varied musical training) rated perceived similarity of transposed melody pairs (2 of 16 variations of a given melody), controlled for number of shared pitch classes. Data analyses (GLM; factor analysis) revealed that serial duration was the largest contributor to perceived similarity, then pitch contour, metre, and tonality. The larger role of temporal factors in similarity ratings may be due partly to the fact that tempo remained constant, whereas melody pairs were transposed to different keys (disadvantaging pitch). Experiment 2 addressed this issue by varying tempo (120 or 180bpm) between pairs, and adding 3-chord cadences as a prefix before each melody (orienting the listener to the transposed key before the melody). Preliminary analyses show that pitch contour is the strongest factor, followed by duration ratio, metre, and tonality. Overall, surface features influenced perceived similarity more than structural, and tempo changes decreased the strength of temporal factors relative to pitch. Conversely, adding chord prefixes to the melodies did not affect the role of tonality in perceived similarity.

[3-18] Pitch perception of time-varying sung tones

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Previous work on pitch perception of time-varying sung tones has focused on tones where the variation occurs through vibrato or the changes in the trajectory of the fundamental frequency (F_0) over the duration of the note (e.g., pitch glides). D'Alessandro and Castellengo (1994, 1995) studied the perceived pitch in short synthesized sung tones with vibrato and found that the end of the note was more influential on the pitch perception than the beginning of the note. D'Alessandro, Rosset, and Piot (1995) studied the perception of tones with F_0 glides of various extents and durations, and found the opposite of the findings by D'Alessandro and Castellengo that the end of the note was more influential on pitch perception. Gockel, Moore, and Carlyon (2001) revisited the finding that certain parts of the tone influenced the perceived pitch more than others. From their experiments with sinusoids, they concluded that the perceived pitch be calculated as a weighted average favoring the more slowly moving portions of a note, rather than taking an unweighted mean over the duration of a note.

This study is the first to consider how the combination of vibrato and changes in the F0 trajectory of the note impacts perceived pitch, as well as the impact of different trajectory shapes. This study examines the impact on pitch perception of sloping and curving F0 trajectory in synthetic vocal stimuli with vibrato. The goal is to better model the variation that occurs in sung tones. The study makes use of an adaptive transformed up-down two-alternative forced-choice paradigm. This differs from the method-of-adjustment paradigm that was used in earlier studies and was chosen because we are interested in assessing the difference between the various F_0 trajectory conditions (combinations of different amounts of upwards/downwards slope and curvature) and vibrato tones with an unchanging F_0 trajectory.

[3-19] Tonal schema learning in an artificial neural network

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A listener identifies a key for a melody on the basis of tonal schema acquired through mere exposure to music. We attempt to propose the model that elucidates the learning mechanism of tonal schema. As the first step, we tested whether a neural network model has the ability to learn the rules of Western diatonic tonal schema similar to those listeners have acquired, by an exposure of a numerous familiar Western musical exemplars. To compare with key responses predicted by trained models, we started with collecting key perception responses from human listeners. Fourteen listeners who differed in musical training years (range=0~17 years), identified keys for 100 famous Western melodies. Inter-subject agreements in key response were below 20% for inexperienced listeners, but to those among experienced listeners increased to 60-80%. Moreover, proportions of key responses conforming to the diatonic structure correlated with training years, $r(12)=.85$, $p<.001$. Three feedforward neural networks were constructed. They shared the same input and output layers but differed in hidden layers (i.e., 1-, 2-, or 3-layers). The input and output layers represented 12 pitch classes and 24 keys, respectively. Each network was trained using 4272 novel familiar Western music and their respective standard key response. After training, each network predicted a key for each of 100 melodies used in the above experiment; subsequently, the consistency rates between keys predicted by each network and keys identified by each human listener were calculated. All networks yielded identical results: The consistency rates (range=5~67%) correlated with musical training years, $r(12)=.86$, $p<.001$, indicating that the neural networks' coincided better with the key responses of experienced listeners than those of inexperienced ones. This suggests, at the present stage, that our neural network models can be a potential explanatory framework for tonal schema learning.

[3-20] The acquisition and generalization of pitch probability profiles

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Krumhansl (1990) has proposed that our sense of tonality is based, in part, on the perception and internal representation of the hierarchies of pitch class salience in music. It has further been proposed that regularities in pitch patterns may be apprehended through statistical learning. To further explore this proposal, we conducted two experiments in which musically untrained participants were exposed to tone sequences generated from one of two pitch profiles: Lydian or Hypophrygian. Tone sequences were randomly generated from event frequency profiles computed by Huron and Veltman (2006), with frequencies converted to probability of occurrence. Exposure trials consisted of 100 sequences generated from one mode for half the participants and from the other mode for the remaining participants. Sequences generated from the unexposed mode appeared in test trials only. Following the exposure trials, testing involved pairing exposed and unexposed tone sequences at each of three levels of distinctiveness. Versions of the tone sequences were constructed to be more or less distinctive following an algorithm described by Smith & Schmuckler (2004). In Experiment 1, participants were asked to record which pair member they preferred and in Experiment 2, participants were asked to record which pair member was more familiar. In both experiments, both groups received the same test pairs. Results of Experiment 1 indicated no preference for any tone sequence type. However, results of Experiment 2 revealed participants had acquired knowledge of the exposed pitch distribution, and were able to generalize to the more distinctive level. The findings support a proposal by Loui, Wessel, and Hudson Kam (2010) that generalization and preference may dissociate in statistical learning.

[3-21] A limiting factor in the accuracy of pitch memory for non-AP listeners

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People who do not possess absolute pitch (AP) often have strong pitch memory and can identify whether a familiar song is in its original key. This study explores the extent of this ability, using pairs of songs in combinations of original and transposed keys. Thirty-five undergraduate students (non-AP) listened to an ordered list of seven *Songs Without Words*, by Felix Mendelssohn, twice per day for one week. During interview sessions, each participant listened to 24 trials containing the final 12-18 s of one song, paired with the initial 15-20 s of another song. Eighteen trials included consecutive songs from the list, while 6 trials used non-consecutive songs. The excerpts, in MIDI format, were presented either in their original keys or transposed (by 1 or 3 semitones); if both excerpts were transposed, they were moved in the same direction. Participants rated (yes/no) whether the excerpts were presented in their original keys. The responses were correct 76% of the time; the percentage of correct responses was greater for consecutive songs than for non-consecutive songs ($p < .01$). In trials with consecutive songs, participants correctly identified the key of the second song more often when it was presented at its original pitch level ($p < .0001$). Furthermore, when both songs in a trial were presented in their original keys, responses were correct 88% of the time; this decreased to 83% when only the first song was transposed, 76% when both songs were transposed, and 69% when only the second song was transposed. Level of transposition did not have a significant effect. Thus, although pitch memory was strong—even with limited exposure—there were more false positive responses than false negative responses. Also, altering the key relationship between songs resulted in a decrease in correct responses.

[3-22] The role of sound-size symbolism in tone perception

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Recent research supports the notion, commonly known as *sound-size symbolism*, that high pitches are associated with small objects, while low pitches are associated with large objects (e.g., Bolinger, 1964; Ohala, 1980). Recently, a number of studies have examined the connection between the two by employing reaction time methods, although with binary choices of "high" and "low" and "large" and "small" stimuli (Evans & Treisman, 2010; Parise & Spence, 2012).

This paper addresses the issues of both pitch range and the possibility of a continuous, rather than discrete, association, and presents a comparison between indirect speeded classification (ISC) and the implicit association tests (IAT) when analyzing audio and visual correlates between pitch height and visual size. The first study was an ISC, in which the audio stimuli ranged from 80Hz to 800Hz, while the visual stimuli included two circles of randomly generated sizes.

A second study used a cross-modal adaptation of an IAT, in which the auditory stimuli ranged from 33 to 4,186Hz . Each participant completed five iterations: the first four presented a 1, 3, 5, or 7 octave difference, while the fifth iteration examined only a 1 or 3 octave difference, placed within a different register. The IAT examines the continuum of pitch differentiation, while also facilitating an analysis of "absolute" vs. "relative" pitch differences in the perception of audio and visual stimuli. Although the results are currently being analyzed, we predict that reaction times will decrease when audio and visual stimuli match, that absolute pitch height will be prioritized over intervallic differentiation, and that larger octave displacements will reduce reaction times. In so doing, this study further explores connections between pitch height and the size of visual stimuli, and discusses the various benefits and pitfalls of both the ISC and IAT methodologies in music research.

SAT

[3-23] Psychophysiological responses to auditory change

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In recent years, the domain of music and emotion has observed the increasing practice of interpreting physiological responses as indices of the affective response to music. However, physiological responses are not specific to emotion processing; they also reflect cognitive processes such as attention and expectation that may be shaped by acoustic factors in music. While numerous studies report the effect of acoustic parameters such as intensity on psychophysiological responses, few examine parameters essential to musical organization, such as pitch, timbre, and rhythmic isochrony. Thus, the present study sought to examine the effect of auditory changes within these parameters on the autonomic and somato-visceral responses of listeners.

Forty participants (20 musicians) were presented with 144 auditory sequences while attached to biosensors measuring respiration rate, heart rate, skin conductance, and facial activity of the smiling and frowning muscles. Each trial consisted of an isochronous sequence of 24 repeated synthesized tones. Following the orienting-reflex paradigm, each trial contained either a change in pitch (m3, TT, M7), a change in timbre (bassoon, trumpet, French horn, obochord), or no change on a given target tone (whose temporal position varied randomly). To assess the effect of deviations from rhythmic isochrony, the target tone was also presented either on or off the beat (on, early, late).

An interrupted time-series analysis indicated that changes in pitch, timbre, and rhythmic isochrony produced significant variations in heart rate and skin conductance. However, there were no effects of auditory change on facial muscle activity, suggesting that somatic activation is less affected by auditory change in these musical parameters than physiological measures related to autonomic nervous system function. The present study should thus serve as an impetus for music researchers interested in interpreting physiological responses as emotional indices to also consider acoustic factors in music that may influence physiological functioning.

[3-24] Don't you forget about me: Thought suppression may lead to intrusive songs

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In many cases, thought suppression–trying not to think about something - ironically makes the thought more likely to return. When a person tries to stop thinking about something, they seem to think about it more than if they had not tried to suppress it. We examined if this effect was present for a song stuck in one's head, an intrusive song.

We investigated this question in two ways. The first was a survey in which we asked participants about the rate of different types of involuntary thoughts including songs stuck in the head, memories, thoughts about relationships, and worries about money. People who reported a higher frequency of one type of involuntary thoughts more often experienced other types of involuntary thoughts. Furthermore, individuals who experienced more frequent involuntary thoughts scored higher on the White Bear Suppression Inventory, a measure of thought suppression tendencies (Wagner & Zanakos, 1994).

The second investigation was an experimental study where we set up a situation where they would naturally suppress the music rather than ask them as in Wagner and Zanakos' (1994) study. Participants either listened to two popular songs or completed a cognitive task while listening. While working on a later unrelated task, participants who worked on a cognitive task reported experiencing more time with intrusive songs in their head than the people who only listened to music in the first task. We found that intrusive songs have a higher rate of returning when attempting to keep the songs out of awareness. This builds on previous research in that thought suppression is not only for visual cues but music as well.

[3-25] Mental transformations of auditory images during vocal imitation

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Imitation is a natural response that emerges early in human development and aides in learning diverse skills, including speech. Despite the importance of vocal imitation to language acquisition and singing abilities, little is known about the mechanisms underlying vocal imitation, even though a small but significant proportion of adults are apparently unable to imitate pitch patterns through singing or speaking (Pfordresher & Mantell, 2009). We report an experiment testing the hypothesis that individuals exhibiting a vocal pitch imitation deficit (henceforth VPID) are less able to generate auditory mental images of pitch. Auditory imagery has been linked to motor planning areas in the brain and may serve a crucial role in the translation between perceptual and action based information (Halpern, 2001; Leaver, Van Lare, Zielinski, Halpern, & Rauschecker, 2009; Zatorre, Halpern, & Bouffard, 2010). A previous study demonstrated that self-reports of the vividness of auditory imagery were lower among VPID individuals than individuals who can vocally imitate pitch accurately (Pfordresher & Halpern, in press). In the present study, we directly addressed the role of imagery in vocal imitation by manipulating the level of difficulty of using auditory imagery associated with a sequence to be imitated. On different trials, participants imitated target pitch sequences exactly, or after mentally transforming the sequence. Transformations (based on Zatorre et al., 2010) could be transpositions, reversals, or shifts of the serial position associated with the starting point. A corresponding perception task tested participants' ability to recognize transformations of target melodies. Data collection and analysis is still underway at this time. We predict that group differences will increase with the difficulty associated with generating an auditory image (i.e., during mental transformations). Comparisons across production and perception tasks will provide information about the specificity of a putative imagery-based deficit.

[3-26] Implication of the right mirror neuron system in the anticipation of a singing judgment

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The perception of movements is associated with increased activity in the human motor cortex. This system may underlie our ability to understand actions, as it is implicated in the recognition, understanding and imitation of actions. Here, we investigated the involvement and lateralization of this "mirror neuron" system (MNS) in the perception of singing. Transcranial magnetic stimulation (TMS) was applied over the mouth representation of the motor cortex in non-musicians while they watched 4-second videos of singers producing a 2-note ascending interval. The task was to decide whether a sung interval matched a given interval previously shown on a computer screen. A control task consisted of judging whether abstract visual figures were open or closed. During both tasks, motor evoked potentials (MEPs) were recorded from the mouth muscle and normalized by considering a ratio of the amplitudes obtained in the singing interval task relative to the control task in each cerebral hemisphere. To investigate the time course of the motor activation, TMS pulses were randomly emitted in 7 time windows (ranging from 500 to 3500 milliseconds after stimulus onset). Results show that the MEP amplitudes are higher after stimulation of the right hemisphere in the singing condition. More specifically, TMS applied between 1000 and 1500 milliseconds, before the production of the second note of the interval, over the right hemisphere yielded higher MEPs as compared to the left hemisphere. These results suggest that the right MNS is involved in the anticipation of a singing judgment.

[3-27] Interactions with musical long-term memory are critical component of musical working memory

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The nature and mechanisms of working memory (WM) for musical information remain poorly understood. The aim of this study is to show that musical WM strongly depends upon long-term memory (LTM) mechanisms and requires access to the long-term musical knowledge base. Two groups of participants (musicians and non-musicians) participated first in an implicit learning task during which they heard for about 30 minutes a continuous sequence of tones governed by a new musical grammar. Then, they performed an immediate serial recall task of musical sequences of increasing length; half of the sequences were constructed in accordance to the rules of the new grammar presented during the implicit learning task. Participants have to reproduce the sequences by humming and their performances were calculated on the basis of the deviation between their production and the stimulus needed to be reproduced. The results showed a significant advantage for the lists governed by the grammar previously learned. Overall, this study shows that performance on a musical WM task is enhanced by musical knowledge stored in LTM. This study is the first to demonstrate the dependency of musical WM on musical LTM knowledge, implying that existing models of musical WM need to be extended to account for this WM-LTM interaction.

[3-28] Differences of musical contexts influence to the detection of deviated tones: An event-related potentials study

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It is said that many Japanese have basic musical sense of western music even if they haven't professional music education because they have been exposed to western music since their childhood. But it's also suggested that it depend on the circumstances of their growth and or their musical experiences. And these individual differences may relate to the differences of degrees of musical schema formation. Which kind of deviation can notice us that some tones deviate during we are listening music? It seems to depend on the formation of the musical context. It has very important role even for the judgment of the simple tone.

In this study, we investigated the effect of the musical context on the judgment of single tone in the cadence using event-related brain potentials (ERPs). MMN, one of the components of ERPs relates to the degrees of deviation of the tone from the context, was used as an index. The tone stimulus consisted with 8 pure tones of C major (C, D, E, F, G, A, B, C), and the deviated tones were made by changing the frequency of E and A. There were two conditions of tone presentation. One was the "random presentation condition (RP)" in which 8 tones were presented in random order, and the other was the "standard presentation condition (SP)" in which 8 tones were presented along with scale. As the results, the sense of the deviation of the tone will be clear in the SP than in the RP, and MMN also larger in the SP because the judgment of the tone are performed in the musical context.

[3-29] An event-related potentials (ERPs) study of the deviation from the musical context using popular music in Japan

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ERP studies for cognitive processing of music have been conducted focused on the specific musical elements as melody, pitch or harmony. A strange chord in the harmony elicits the sense of deviation from musical context. An ERAN component in ERPs reflecting the deviation from musical context was reported. And more, the EAN component in ERPs was suggested to reflect the deviation from the rule of harmony.

In the present study, whether the ERAN and or the EAN can be observed in the daily music same as in experimental harmony, were investigated. 10 popular music were used as musical stimuli, and were presented via speakers in front of the participants. There were 4 experimental conditions: some tones were deviated from harmony, deviated from melody, deviated from both harmony and melody and not-deviated. Participants were instructed to watching the silent video and ignore the music during experimental session and EEGs were recorded. After the experiment, participants estimated the degrees of familiarity of the music using mark sheets.

ERPs to the deviated tones in 3 deviated conditions were analyzed compared to the no-deviated condition. We focused the ERAN and the EAN elicited to the deviated tones at about 200ms after tone onset. The differences of these ERP components related to the kinds of deviation were expected.

[3-30] Does the ERAN reflect the difference of musical exposure to Western tonal music?

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The aim of present study was to investigate the difference in building of the musical context between musical cultures with event related potential (ERP). The processing of musical syntax has been reported to be reflected in an early right anterior negativity (ERAN) which is evoked by stimulus deviant from musical context, and maximal around 200ms after stimulus onset. The amplitude of the ERAN is clearly larger for musical experts than for novice, presumably because experts have more specific musical expectancies than novice. Recently, in

musical education at school in the most of countries, Western tonal music is used. Most of the melodies or harmonies in Western tonal music are normally based on a harmonic structure that refers to one single key. But the effects of exposure to Western tonal music may differ among Asian countries, possibly because of different musical cultures. In this study, Japanese, Korean, and Chinese participants listened to stimuli which were 150 chord sequences, each consisting of five chords. In all experimental cadences, the first chord was always the tonic. As deviated stimuli, Neapolitan chords were inserted at the third and fifth position of the cadence occurring with a probability of 10%. All chords consisted of synthesized piano sounds played under computerized control via MIDI, and in 10% of the cadence, an in-key chord at the second, third, fourth, or fifth position was replaced by sounds played by another instrument (harmonica). Participants' task was reporting the number of chords played by harmonica after the experimental trial. ERPs recorded from Japanese, Korean, and Chinese participants were compared.

[3-31] The effect of presentation mode on cross-cultural music memory performance

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Visual information has been observed to affect the success with which musical features are remembered. Memory for such structural characteristics as pitch and tempo may even be misremembered or misidentified as a result of particularly salient visual images. In the case of music presented in audio-only format, listeners may augment auditory incoming stimulus by generating an internal image of the performance thus enhancing encoding and, ultimately, recall. It may be speculated that the ability to generate such an image may offer a memory advantage for music that features familiar contextual characteristics (e.g., familiar genre or instruments).

This study tests whether inclusion of video along with audio information results in improved memory for culturally unfamiliar music. Participants will hear (audio condition) or watch and hear (AV condition) performances of excerpts from 4 different pieces of Western and Chinese classical music. US-born adults will be asked to indicate preference for each excerpt and subsequently complete a memory task in which they identify whether each of a series of test items had been heard as part of a previous excerpt. Test items will be presented in audio or AV format resulting in three possible excerpt-response pairings: audio/audio, AV/audio, AV/AV.

Preliminary results demonstrated significantly better overall memory for culturally familiar music excerpts. For culturally unfamiliar music memory scores were better in the audio presentation condition than in the AV presentation condition. Participants demonstrated a significant preference for culturally familiar music excerpts and slightly more positive, though non-significant, evaluations in the AV presentation mode.

These findings suggest that culturally unfamiliar visual information coupled with culturally unfamiliar auditory information does not facilitate better music memory. Contrary to our speculation that multimodal stimuli would enhance auditory memory performance, it is possible that the combination of audio and visual information offered too much novel information for effective encoding.

[3-32] Differences of the sense of deviation from musical context between Japanese and Western musical scale: An event-related potential (ERP) study using native Japanese

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Most studies relate to the musical context were performed about the deviation from harmony and or melody. Specific musical elements as melody, pitch or harmony have been focused in ERP studies. For example the ERAN component to the deviated strange chord in the harmony was reported.

In previous studies, musical stimuli base on the western tonal music have been used. But in each country, there exist original music differ from the other country, and peoples mainly exposed by the native music. Therefore it is important to know the character of the music for conducting experiment.

In Japan, there are specific traditional Japanese musical scale (ex. "Sakura Sakura") differed from Western's. Although most Japanese are exposed mainly to the Western music in the daily life, the Japanese musical scale also may influence to the processing of the music.

The aim of this study was to investigate the effect of musical scale using ERPs. Stimuli were 2 kinds of melodies, one was of Japanese (native) scale and the other was of Western (non native) scale. They were presented via speakers in front of the participants. Participants were instructed to listen to the melody carefully, and EEGs were recorded. In both scales, finalis of the melody was deviated in frequency and or in timing compared to standard melodies.

ERPs to this finalis were analyzed about amplitude and latency. Modification of ERPs relate to the scale difference and degrees of exposure to the music in daily life are expected.

Sunday 11 August

Talk Abstracts

[4A-1.1] More is not less: Extra-musical information and music preference

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Listener music preferences are complex and influenced by a variety of musical and extra-musical factors. This research investigated the role of newly learned extra-musical information on a listener's subjective preference for a given piece of music. The experimenter created "mock" TV music listening channels similar to the commercially available "Music Choice" channels. These music channels play various types of music over relatively static visual information, which often includes: artist name, song title, album title, a picture of the artist or album, and extra facts about the artist. These extra facts provided a variety of extra-musical information about the song or artist, including historical information, personal stories, artist quotes, etc. The manipulation in this study was the number of shared "facts" that were presented with each piece. The experimental software randomly paired 0 to 4 facts with each song. Participants, who were unaware of the experimental manipulation, were asked to watch several music channels and provide ratings of subjective preference for each piece. Results test the hypothesis of a positive correlation between the number of presented extra-musical facts and subjective listener preference. Follow-up studies will investigate not only the "quantity," but also the "type" of extra-musical information needed to influence a listener's subjective musical preference.

[4A-1.2] Retro Sequential Practice (RSP) – Neuroscientific aspects of a music practice method

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In everyday life musicians of all genres and levels facing multiple challenges practicing their instruments. The research by related sciences showed, that accomplishing those tasks strongly depends on the degree of automatization of a musician's motor and cognitive skills. Accordingly, most practice methods suggest start practicing in lower tempi – usually from the top of the musical piece, section or phrase.

Nevertheless, the design of anterograde practice (AP) seems to bear some problematic implications, which may impair the efficiency of the musical learning process. Consequently, Retro Sequential Practice (RSP) draws some attention as a music practice method, that is trying to approach those problems more successfully by focusing on the primary automatization of the terminal sequences of a musical object and its stepwise (sequential) backward (retro) oriented expansion.

The study is conducted in form of a empiric field study that is still in progress and includes students of differing ages, levels of expertise and musical goals. All participants were tested on RSP and AP by practicing different pieces. The sessions were videotaped and supplemented by oral interviews. First, the analysis of the footage helped to indicate the main problems in AP. Furthermore, to point out the distinct differences of AP and RSP, their key features were portrayed, analyzed and discussed. Finally, in order to explain the possible advantages of RSP, the empiric findings were interpreted and discussed regarding to neuroscientific research results.

The findings and their neuroscientific interpretation suggest, that RSP supports the learning process, particularly regarding to accomplishing of complexity and structuring of learning content, specifying of perception and sharpening of imagery, enhancing of retention and accelerating of skill development, strengthening of self-confidence, intrinsic motivation and improving stage presence.

Thus, RSP optimizes the musical learning effect by conclusively aligning instrumental practice according to neurophysiological and neuropsychological facts, conditions and phenomena.

[4A-1.3] Quantitative analysis of the vibrato patterns of ten expert violin performers

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Vibrato is an indispensable and complicated technique that is not only difficult for student violinists to master, but is explained by diverse theories stemming from different pitch perception theories and physiological motion concepts. This study applied an analytical method to analyse how vibrato is played by ten renowned ten expert performers on published CDs. The vibrato patterns were categorized based on the obtained quantitative data. Two parameters were examined: (a) the type of frequency variation and (b) the corresponding frequencies with the highest intensities during all cycles in a vibrato note. The results show that the ten experts produced vibrato with three distinct types of frequency variation, but in all cases the frequency with the highest intensity during all cycles was closely aligned with the target frequency. The intensity of the target frequency appears to be the crucial factor for achieving good intonation when playing vibrato. The results of this study can provide students and teachers with quantitative data for communicating and rethinking their learning and teaching of vibrato techniques, as well as how they should adjust their technique in order to improve the intonation.

[4A-1.4] The influence of a visual performance component on preference ratings in response to complex musical sound

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The purpose of the present study was to determine whether the presence of a visual performance component enhances to a significant degree the music listening experience of the listener-viewer in response to examples varying in the level of musical complexity, genre (jazz and art music), and stimulus presentation condition (audio only, audio with algorithmic visualization, or audio with visual performance data). Results of three experiments will be presented, each building upon the results of the previous. In addition to the primary results sought, the presentation will also address design issues that emerged and were revised in order to improve the reliability and validity of the experimental procedures. In later experiments, a block design (rather than independent groups) was utilized so that every participant experienced excerpts not only of each musical genre (jazz and art music), but stimuli representing each of the three A-V conditions (enumerated above). Quantitative data in the form of verbal scale responses were collected, along with responses to open-ended questions that revealed the underlying rationales for ratings provided by participants. Results of the investigation revealed a clear preference for less complex music, but also confirmed that adding a visual component (either performance data or algorithmic visualization) resulted in higher ratings for complex musical examples. Presenters will address relevant implications of this outcome when introducing music in the classroom that falls outside the "comfort zone" of students enrolled.

[4A-1.5] Emphasizing salience: Promoting the role of secondary musical parameters in undergraduate music theory

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Empirical evidence suggests that when most listeners are asked to identify similarity between musical passages or degree of tension, they tend to notice secondary musical parameters (timbre, dynamics, tempo, etc.) more than primary parameters (harmonic patterns, rhythmic-metric structures, etc.) (Cupchik et al., 1982; Lamont & Dibben, 2001;

Novello et al., 2006, 2011; Eitan & Granot, 2009; Farbood, 2012). This prioritization of secondary parameters appears to be the result of a perceptual salience inherent to the parameters themselves, perhaps because of their important role in extra-musical auditory perception (processing of speech and identification of environmental sonic cues). Nonetheless, undergraduate music theory textbooks clearly prioritize the study of primary parameters, most particularly harmonic structures. This focus, however, runs the risk of neglecting the role of secondary parameters in the experience of harmony itself and in music in general, thus distancing the study of music theory from the non-specialized listening experience. In this presentation, I lay out empirical evidence supporting the notion that harmony is not as perceptually salient as other musical parameters in non-specialized listening experiences; in addition, I suggest ways in which these findings of empirical research can be used by theory instructors and shared with theory students without threatening the central role of harmony in the theory curriculum. I argue that such openness to the potential problems of over-focusing on harmony can promote the discussion of the interaction between harmony and other musical parameters.

[4A-2.1] Beat it! The effects of music and beat on recall of a dance sequence

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There are mixed results for the benefits of music in learning and recalling a dance sequence. Music offers a temporal structure for movement timing, along with a foreground of melody, harmony and timbre. Such features may act as cues to the phrasing and dynamics of a dance routine that has been choreographed to the music. Evidence suggests that expert dancers are able to use full music cues to remember specific steps whereas for novice dancers only the beat structure is useful for dance learning and memory. To investigate such effects under controlled conditions, a 2 x 4 design crossed training conditions (music, beat – between subjects) with testing conditions (original music, beat, new music, silence – within subjects). The task involved 54 novice dancers learning and recalling a novel 32 s dance-pop routine constructed from eight different steps. One group trained with a fully intact musical piece, composed to match the dance structure in terms of phrasing and timing; a second group trained to the beat track of that music. All participants recalled the dance sequence in four counterbalanced conditions: the original music, the original beat track, a new and different fully intact musical piece with the same beat, and silence. Competing hypotheses were that if music cues aid memory, full music at training and testing would result in the greatest dance accuracy, or if beat alone aids memory, then beat at training and testing would result in the greatest accuracy. Results indicated that beat provided a greater memory advantage for the recall of dance-pop steps than music and, contrary to prediction, for those who trained to full music, silence provided an advantage at recall over all other recall conditions. Findings are discussed in terms of temporal cues and cognitive load.

[4A-2.2] Increased affiliative behavior in infants following interpersonal musical movement

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Musical behavior (e.g., dancing, singing, playing musical instruments) encourages high levels of interpersonal co-ordination, and has been associated with increased group cohesion and social bonding between group members. Specifically, individuals who walk, sing, or tap together are subsequently more helpful, compliant or cooperative in later interactions with one another. The developmental trajectory of this social effect of interpersonal coordination is still unclear, but we do know that certain abilities necessary for engaging in musical behaviors with group members mature during the first year after birth. A 5-month-old infant may spontaneously move rhythmically when listening to musical beats. Also, a 7-month-old infant's perception of meter in a beat pattern is influenced by the way that infant is passively bounced to these beats.

The current study investigated whether the social evaluations by 14-month-old infants are influenced by cues of interpersonal motor synchrony to music. During testing, Experimenter 1 held a 14-month-old child in a child carrier facing outwards. This experimenter bounced the child to either predictable (isochronous beats) or unpredictable (non-

isochronous beats) versions of a melody played over loudspeakers while Experimenter 2, facing the child, bounced either synchronously or asynchronously with the infant. Following the bouncing phase, Experimenter 2 performed a few short tasks during which the child was given the opportunity to help by handing accidentally dropped objects back to her. A main effect of interpersonal synchrony on helping behavior was found. When controlling for individual differences as measured using the Infant Behaviour Questionnaire, infants from the 'synchronous interpersonal movement' condition were significantly more likely to help Experimenter 2 than infants from the 'asynchronous interpersonal movement' condition, $F(1,36)=4.92$, $p=0.03$, $M=51\%>33\%$. These results suggest that the cue of interpersonal motor synchrony, one that is highly salient during musical engagement, affects social evaluation even very early in development.

[4A-2.3] The influence of music-dance synchrony on eye fixations and dwell times

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In a previous study investigating entrainment and person perception, in-tempo dancing with others was found to enhance memory for incidental person attributes (Woolhouse & Tidhar, 2010). The experiment used 40 dancers (all of whom were unaware of the experiment's aim), multi-channel silent-disco radio headphones, a marked-up dance floor, two types of music, and memory identifiers (sash colors and symbols). In each trial, 10 dancers wore radio headphones and different colored sashes, some of which carried symbols. Using "silent-disco" technology, one type of music was surreptitiously transmitted to half the dancers, while music at a different tempo was transmitted to the remaining dancers. Pre-experiment the dancers' faces were photographed; post-experiment each dancer was presented with the photos of the other dancers and asked to recall their memory identifiers (sash color and symbol). The results showed that in-tempo dancing significantly enhanced memory for sash color and symbol.

Although the memory effect outlined above was robust, the process(es) by which it is actuated is/are not known. In this current study, two hypotheses were investigated: that enhanced memory for person attributes is the result of (1) increased gaze time between in-tempo dancers, and/or (2) greater attentional focus between in-tempo dancers. To explore these possible mechanisms, the research moved from the dance floor to an eye-tracking lab. Here subjects watched videos of pairs of dancers in which only one of the dancers was synchronized with the music, the other being asynchronous. The results were consistent with the first hypothesis: that music-dance synchrony gives rise to increased visual inspection (dwell/gaze) times. In addition, the data show a preference for torso- and head-directed (rather than lower part-directed) fixations across both synchronous and asynchronous conditions. Results of inter-onset tapping intervals collected form the subjects as they watched the videos are currently being analyzed to determine the possible affects of audio-dance (a) synchrony on motor control.

[4A-2.4] Musical actions: Windows into time

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In contemporary theories of musical time, it is usually recognized that, in our everyday experience, time is contingent on the experience of motion. But what kind of motion do listeners experience in music? While typically answers are sought in the medium of sound, in this paper I propose that one promising approach is to consider listeners' actions as a window into musical time. My aim is to demonstrate that the experience of musical time is embodied, and that music-accompanying actions – both enacted and simulated – present us with an opportunity to empirically study a phenomenon that is supremely subjective from the perspective of listeners. I will show that the lived experience of time can be considered as a mechanism for coping with the temporal affordances of the environment, and as such, can be examined through the lens of Gibson's theory of affordances.

The theory I present here is based on the results from motion capture experiments in which participants were asked to move along with musical excerpts. By looking at actions to both metrically and non-metrically organized sounds, we find that there are two distinct strategies that listeners employ in dealing with the temporal structure: one of synchronization, and one of coordination. The timing skills involved in coordinating one's activities to external stimuli –– including social behavior –– are crucial in how humans operate in their environment. I propose that the two modes

of timing one's motor actions correspond with two different experiences of time, where coordination engenders a subjective present, while synchronization forms the basis of intersubjective time. The methodology and theory outlined in this paper allows researchers to consider movement to non-metrical, free-rhythmic music as part of artistic activity that builds on motor behavior typically found in everyday interactions with events in our environment.

[4A-2.5] Learning to play the cello: An analysis of 3D movement and the effects of visual and auditory feedback throughout the learning process

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How do musicians learn to translate their motions into the sounds we hear as "moving" music? What does a more advanced player do differently from a beginner? Little research has explored the intricate movement patterns crucial to music performance, and particularly the acquisition and development of motor skills during the learning process. A handful of recent studies have tested the potential of visual feedback to hasten learning of various musical performance parameters. Can visual feedback on 3D movement patterns in cello performance benefit teaching and learning practices?

The aims of this study are twofold: 1) to describe quantitatively and qualitatively the movement skills underlying beginner cello performance and their evolution with practice; and 2) to explore how visual feedback of motion capture data might inform or enhance the teaching and learning of motor skills in cello performance.

Eight university music students were taught to play a new instrument, the cello, for one month. Lessons were video-recorded, and sample performances from each were recorded using 3D motion capture and audio technologies. Participants periodically received either auditory or auditory plus visual feedback of their own performances. Practice logs, interviews, and questionnaires elicited additional information on participants' challenges, development, and perceptions of technology-enhanced feedback.

This study presents a first investigation of beginner cello playing technique both within and between participants as they learn. Gaining a deeper understanding of playing movements, and the process whereby musicians "fine-tune" these and the sounds produced, has significant implications for teaching and practice strategies. Accurate information may help rectify established pedagogy at odds with principles of healthy movement and reduce the prevalence of playing-related injury, largely attributable to preventable technical faults. Since cello performance is an example of highly coordinated and repetitive movement, these investigations may be of interest in the fields of cognition, neuroscience, occupational injury and rehabilitation.

[4A-3.1] Neurodynamic constraints on musical languages

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Since antiquity, musicians and scientists have asked whether mathematical relationships among acoustic frequencies govern the perception of musical relationships. Early psychophysicists rejected this approach, citing evidence that the auditory system performs a linear analysis of sound. Cognitive psychologists have since focused on long-term exposure to the music of one's culture and short-term sensitivity to statistical regularities. Today evidence is rapidly mounting that the auditory system is highly nonlinear, inviting reevaluation of the role of frequency in cognitive accounts. These findings lead us to a dynamical systems analysis of auditory nonlinearities that predicts substantive universals in music perception and cognition. We show that this approach combines with short and long-term learning to explain perceptual ratings of Hindustani raga not only by encultured Indian listeners, but also by Western listeners unfamiliar with North Indian music. Thus, universal properties of neural oscillation explain cross-cultural invariants in the perception of tonal music, implying neurodynamic constraints on the acquisition of musical languages.

[4A-3.2] A brain index of harmonic integration in the perception of tonal melodies

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The importance of harmony in the perception of tonal melodies has been extensively explored, but little is known about the processing of implied harmony. Previous behavioral studies (Kim, 2009; 2011) showed that sing-back reaction times were longer when more effort was needed for harmonic integration. RTs were longer for unexpected chord tones than for expected ones, and for chord changes at unexpected times than those at expected times. RTs, also, became shorter as implied harmony became clearer over the time course of a melody. The current EEG study investigates neural correlates of the processing of implied harmony. The context melodies were six 15-tone sequences. Each consisted of five groups of three consecutive tones that belonged to the same chord. The context always implied I-V-I-ii-V progression. Four kinds of endings followed the context. The ending implied either I (expected) or IV (unexpected). Additionally, the final implied harmony could change on the 16th tone (on-time) or on the 15th tone (one-beat early). 20 participants heard 24 melodies (6 context melodies x 4 endings) in 12 transposed repetitions. They detected timbre-deviant tones by pressing a button and were not informed about the harmonic manipulations. A late frontal negativity peaking around 470 ms was larger in amplitude for unexpected chord tones than for expected ones, and for early changes than for on-time changes. Thus, ERP results to date have confirmed the RT trends found in the previous behavioral studies. Since the amplitude was larger when more effort was needed for integrating new events, this late negativity can be interpreted as a brain index of harmonic integration in the perception of tonal melodies. In addition, we are currently examining the effects of tone position (for all 18 tone positions) and of chord-transition probabilities (for all five chord changes) on the latency and amplitude of the late negativity.

[4A-3.3] The influence of various tonal contexts on memory for single notes

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Two theoretical accounts can explain how a tonal context might influence memory for single notes in a melody. The *schema theory* posits that a note would be better remembered if it is highly expected within a certain tonal schema (i.e., musical key). Furthermore, this theory suggests that highly expected notes would be more prone to being falsely remembered. A second account is based on the *von Restorff effect* (1933), wherein isolating an item from its background enhances memory for that item during recall. Therefore, unexpected notes would be better remembered because they "pop out" of their surrounding tonal context. To test these accounts, we conducted four experiments. In Experiment 1, participants heard a series of major-key melodies and indicated whether or not a probe note appeared in the preceding melody. The melodies were manipulated along two factors: probe note (#5, M6, P5; chosen to generate expectations of varying strength based on the given melodic context), and presence of probe note. Experiment 2 was identical to Experiment 1, except that we used minor-key melodies instead of major-key ones to weaken the tonal context. In Experiment 3, we used a delay because previous work has shown that memory for notes improves at long delays. Finally, in Experiment 4, we used atonal melodies to completely eliminate the tonal context. The results showed better performance for the P5 and #5 within a major context (Experiment 1), which is explained by both the schema theory and the von Restorff effect. Interestingly, these effects largely disappeared within a minor context (Experiment 2). Experiment 3 showed that a delay results in generally worse performance, as indicated by low D-prime and high false alarm rates. Finally, Experiment 4 yielded surprising results, as participants showed better memory for P5, despite the lack of tonal information.

[4A-3.4] Oscillatory neurodynamics explain perceptual differences between melodic steps and leaps

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The distinction between steps and leaps is essential to the structure of tonal music. It defines the ways harmony and voice-leading combine to build hierarchically elaborated structures out of simple underlying structures. Music theorists observed that the second tone of a melodic step tends to displace the trace of the first leaving only one trace in memory, whereas the second tone of a melodic leap tends to support the first (Larson, 1997). Empirical studies have confirmed both the inhibitory effect of melodic steps (Deutsch & Feroe, 1975) and the supportive nature of melodic leaps, especially those based on simple integer ratios (Schellenberg & Trehub, 1996). Here we show that the distinct perceptual nature of steps and leaps can be explained by the basic properties of neural oscillation. When neural oscillators of close natural frequencies are coupled, they can have interfering effects on each other. On the other hand, when the natural frequencies are well separated and form a ratio approximating a simple integer ratio, the oscillators can resonate in a mode-locked state. To demonstrate, we build a computational model of pitch memory using a canonical model of neural oscillation. The model system consists of multiple layers of neural oscillators whose natural frequencies are tonotopically organized. The lowest layer is driven by melodic sequences and the activities in the top layer are interpreted as the traces in pitch memory. Nonlinear coupling between oscillators leads to interference between adjacent frequencies as well as mode-locked resonance between distant frequencies near a simple integer ratio. We demonstrate that the oscillator network model replicates the empirical findings on melodic steps and leaps and provides fresh insight into melodic phenomena such as melodic embellishment and compound melody.

[4A-3.5] Knowledge of Western pitch structure: Explicit measures are more sensitive than implicit measures to effects of experience

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Knowledge of key membership and harmony is acquired through exposure to music even without formal instruction. As such, measures of musical knowledge should be sensitive to amount of exposure, which varies as a function of age and formal training in music. We examined the effects of music training on two behavioral tasks in 10- and 11-year-old children. Half had at least 12 months of music lessons. The others had no lessons. In the test of implicit musical knowledge, children judged whether the last chord in a 5-chord sequence was played on a piano or guitar. The last chord was either expected or unexpected (key deviant in one block, harmony deviant in the other). In the test of explicit musical knowledge, children judged how good or bad the same sequences sounded using a 5-point rating scale. For the implicit task, children were slower to respond to unexpected compared to expected endings but there was no effect of music training. By contrast, for the explicit task, effects of music training were evident. The difference between ratings for expected and unexpected trials was larger for musically trained than for untrained children. Our results suggest that both implicit and explicit behavioral tasks measure knowledge of Western pitch structure, but explicit tasks are more sensitive to the effects of experience.

[4A-4.1] Hooked

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What makes music "catchy"? Despite the prevalence of this concept in popular discourse about music, it has been relatively little theorized and relatively little studied empirically. One reason for the lack of empirical studies may be the scale of the experiment: There seem to be too many potential variables to test and too wide a range of potential stimuli for traditional lab-based experiments to be logistically (or financially) feasible. Internet-based experiments,

however, offer a compelling alternative, especially when large numbers of subjects are necessary (Honing, 2010); moreover, music is a topic that lends itself particularly well to recruiting large numbers of subjects by making an experiment enjoyable enough to frame it as a game.

We will present "Hooked," a game that shall serve as an Internet-based experiment to identify which cognitively relevant musical features affect the appreciation, memorization, and recall of music (Honing, 2010). The game is based on technology from Spotify, which will offer subjects a practically limitless pool of musical stimuli and experimenters useful knowledge about the music with which subjects are most familiar. Subjects shall alternate between a prediction task, where they must choose which of two fragments from a familiar song is catchiest, and a recognition task, which will measure the amount of time it takes subjects to recognize familiar tracks when they are played back starting from various time points. We will then analyze these data against various psychoacoustic or musical features that correspond to some of the existing theories about hooks (see Burns, 1984, for one such list).

We expect to formulate the first empirical, cognitive model of the musical hook. Such a model will be a scientific contribution itself, but we also hope to use the model to help listeners navigate large collections of potentially unfamiliar music, e.g., at national archives.

[4A-4.2] Catching the lyrics: The intelligibility of lyrics in twelve genres

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Although purely instrumental music is commonplace, most of the world's most popular music is sung with lyrics. However, it is evident that listeners don't always attend to the lyrics and that those who do aren't always successful in deciphering them. Previous research has suggested that singing may reduce the intelligibility of words by as much as 70% compared to speaking (Collister & Huron 2008). This previous research was done with artificial musical stimuli. This presentation reports on an empirical study intended to measure the intelligibility of lyrics in real music from a variety of genres.

Twenty participants were exposed to 120 brief musical excerpts from twelve song genres: Avante-Garde, Blues, Classical, Country, Folk, Jazz, Musical Theater, Rock/Pop, R&B, Rap, Reggae, and Religious. After hearing each excerpt once participants were instructed to transcribe the lyrics. The transcribed lyrics were then compared to the actual lyrics and intelligibility scores calculated. The different genres were found to exhibit significantly different levels of lyric intelligibility, from as low as 48% to as high as 90%, with an overall average of close to 70%. The genre listening preferences of each participant were correlated with their intelligibility scores for each genre. Errors were analyzed to determine the effects of vowel choice, consonant errors, rhythmic setting, melismas, and accompaniment on intelligibility. Repercussions for text-setting are discussed.

[4A-4.3] The chorus effect: Tonal complexity and memory for popular songs

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Twentieth-century American popular music is an excellent corpus with which to test hypotheses about music cognition and creativity. Market forces, listener preferences, and artistic choice have led to a moderate amount of standardization of popular-song formats from 1900 to the present day (cf. Hass, 2011; Hass & Weisberg, 2009). At the same time, the tonal complexity of such music has been found to vary from composer to composer, vary over historical time, and account for a significant portion of the variance in the number of recordings of the song (Hass & Weisberg, in review). Recently, Krumhansl (2010) examined listener reactions and memory performance using a sample of 28 popular songs and found that listeners can retrieve a rich tapestry of information from even the briefest exposures to familiar songs. The current study examined the variation in tonal complexity of those 28 songs according to the hypotheses that (1) memory accuracy is improved for songs with less tonal complexity in the chorus, (2) differentials in tonal complexity between chorus and non-chorus sections of melody drive preference ratings and impact of popular songs. Monophonic MIDI files of one chorus and one non-chorus (verse, A', bridge, etc.) were constructed using Logic Pro 9, and tonal complexity was defined as the best key score from the

probabilistic key finding algorithm created by Temperley (2007). Preliminary analysis indicated that chorus sections were significantly less tonally complex than non-chorus sections. Further analyses aimed at testing the two hypotheses will be performed on the Krumhansl sample, and extended to a sample of early 20th Century popular music. Implications for music cognition, memory, and creativity will be discussed.

[4A-4.4] Contributions of perceived and objective musical attributes to a theory of music taste

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Recent years have witnessed an increasing interest in unveiling the origins of music taste. However, the unique contributions of objective versus perceived musical attributes to music taste are yet to be determined. In addition, a growing body of research seems to confirm the validity of web-based studies in music perception (e.g. Rentfrow et al., 2012). The aim of the present study was to examine the relationships between perceived and objective musical attributes, and their respective roles in music taste of individuals without a musical background. 50 short music clips representative of various music genres were presented to online participants. Computer extraction of physical properties of the music using the MIR Toolbox was used to measure objective attributes (dynamics, tempo, rhythm, timbre and tonality). Perceived musical attributes were assessed by self-reports of tempo, loudness, percussiveness, and timbre. *Study 1.* Two independent samples were asked to report their perceptions of the musical attributes. Liking for the music was also rated by the participants. Using stepwise multiple regressions, results revealed that objective attributes explained between 29 % and 67 % of the variance in participants' perceived attributes. In turn, perceived attributes explained about one third of the variance in music taste. Extracted attributes added between 5 % and 15 % of variance in taste. *Study 2.* 11,992 subjects were asked to rate their liking for the same clips. 15% of the variance in taste was attributed to the perceived attributes of Study 1. The extracted features explained a further 24 % of variance. In both studies, extracted and perceived musical attributes were important predictors of music taste. In addition, extracted features were consistently related to laypeople's perception of comparable features. The importance of musical characteristics in the development of a general theory of music taste will be discussed.

[4B-1.1] Electroacoustic music perception: Testing the dynamic ramp archetype via forward and backwards presentations of Stockhausen's Studie II

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Music perception research investigates many different styles of music, but one style that is often neglected is electroacoustic music (EA). Perception is an important topic within the EA community, partly due to the view that perception serves as the only compositional limitation. This study investigates a core feature of EA music: dynamic manipulation. Research has suggested that many musical styles employ a dynamic ramp archetype, in which crescendo length is significantly longer than decrescendo length. Evidence in support of this hypothesis is often based on information from music notation (Huron, 1992). This study extends research on the dynamic ramp archetype by measuring amplitude in musical recordings (rather than written scores), and by directly testing listener preference for the dynamic ramp archetype. Excerpts taken from Stockhauen's *Studie II* were presented, both forwards and backwards, to participants. Most musical elements in this piece remain intact regardless of the direction of presentation. However, backward presentations reverse the length of the crescendos and decrescendos within the excerpt. Participants listened to several excerpts and then rated three different subjective aspects of the music: perceived strength, listener interest, and the music's ability to hold the listener's attention. Results from the forward and backward presentations were then compared to show relationships between musical dynamics and listener perception. The results test the hypotheses that the dynamic ramp archetype is perceived by listeners as being stronger, more interesting, and more capable of holding listener attention than a reverse dynamic ramp archetype.

[4B-1.2] Coordination in musical tension and liking ratings of scrambled music

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In this paper we explore individual differences between real-time ratings of musical tension and liking. The data examined are derived from two experiments in which participants responded to an excerpt from Brahms' Piano Concerto No. 1 that had been segmented and scrambled at different timescales: measure, phrase, and section.

In the first study, participants reported their degree of liking continuously while listening to the stimuli. In the second experiment, participants reported tension continuously for the same stimuli. Overall, tension ratings were much more coordinated than the liking ratings. Though the segments of various sizes were carefully cross-faded to make the transitions smooth and metrically coherent, many align with sharp decreases in both liking and tension ratings, suggesting that participants noticed the breaks in large-scale structure, and found them to be frustrating. The different scales of scrambling provoked different coping strategies as expressed by these ratings; for liking ratings of the phrase and bar-level scramblings, some subjects persisted in expressing specific liking ratings for each individual audio segment, while others reported more large-scale like or dislike for these modified versions of Brahms.

In addition to behavior at the boundaries, this paper will also share examples of how the different segmentations and orderings affect ratings of specific musical moments. These explorations provide supporting and complementary evidence for how listeners process structure at different timescales and in different musical contexts.

[4B-1.3] Perception of large-scale structure in music: Three studies examining brain and behavioral responses to music scrambled at multiple timescales

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There has been considerable debate concerning the extent to which listeners perceive musical structures beyond a short time window. Various studies have shown that listeners are not very sensitive to temporally scrambled music, and that scrambling has limited impact on perception of tonal coherence (Eitan & Granot, 2008; Granot & Jacoby, 2011; Karno & Konečni, 1992; Lalitte & Bigand, 2006; Marvin & Brinkman, 1999; Tillmann & Bigand, 1996; Tillmann, Bigand, & Madurell, 1998). Despite the apparent temporal limitations of tonal processing, the question still remains whether there are other "form-bearing" structures in music that might contribute to global perception of musical coherence (Deliège, et al., 1996; McAdams, 1989; McAdams & Matzkin, 2001; Spitzer, 1996; Tan & Spackman, 2005).

This paper discusses data from three experiments that examine real-time responses to a 4'15" Brahms excerpt scrambled at multiple structural timescales. Subjects in all three studies listened to the original excerpt as well as versions scrambled by measure, phrase, and section. In the first study, musically trained subjects (N=15) were scanned in an fMRI session while listening to the different scrambled versions. In the second study, subjects (N=22) provided discrete and continuous aesthetic judgments of stimuli. In the third study, participants (N=29) provided continuous judgments of musical tension.

Both the brain imaging and behavioral data show clear differences in the how listeners process music scrambled at different hierarchical levels. T he most surprising finding is the substantial difference, in both the fMRI and behavioral measurements, between the original, unscrambled excerpt and the section-scrambled version; the latter consisted of sections that were an average of 38s in length. These results indicate that listeners respond to musical structures that project over considerable time spans, reaching markedly beyond the limited duration of short-term memory. The results also support the notion that interaction between tonal and other structures such as motivic material and texture are critical to the perception of large-scale musical form.

[4B-2.1] Musical topics and the affective differentiation of surprise

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Expectation has been held to be a primary generator of musical affect, yet the exact mechanics of this relationship remain unclear. The experience of listening to music does not seem merely like a series of smaller and larger surprises; quite the contrary–music can seem intense, expansive, gloomy, arousing, and any of a number of other adjectives. Surprise may lurk behind all of these diverse percepts, but how does it get registered phenomenologically in such various ways?

This study looks to the theory of musical topics (see Mirka, forthcoming) for a possible explanation. Listeners without formal musical training heard 8 excerpts of 18th century music, each of which represented one of 4 musical topics – siciliano, tempesta, singing style, or brilliant style. Each excerpt was heard in two versions – one normative, and one with a surprising general pause inserted before the cadence.

Listeners used a dial to continuously rate a single expressive aspect of each excerpt as it progressed. On separate trials, they continuously rated each excerpt's tension, its playfulness, its ominousness, and its sublimity.

Results demonstrate that the expressive inflection of the surprising event (the pause) depends on the topical context; the added pause elevates perceptions of tension, playfulness, ominousness, and sublimity only when placed in the appropriate context. Musical topics, in other words, can form a lens through which surprise is differentiated into distinct phenomenological experiences.

[4B-2.2] Confusing sadness and relaxed musical expressions: Animal signaling versus speech prosody interpretations

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It has been common to regard speech prosody as a template for affective expression in music (e.g., Juslin & Laukka, 2003). When researching prosody, Kraepelin (1899/1921) identified a number of features characteristic of sad speech: slow speaking rate, low overall pitch, quiet dynamic, monotone pitch movement, mumbled articulation, and dark timbre. These same features have been observed in nominally sad musical compositions (e.g., Schutz et al., 2008; Turner & Huron, 2008; Post & Huron, 2009; Ladinig & Huron, 2010). However, all of these features are plausible artifacts of low physiological arousal (Huron, 2012). In this paper, we use both a production study and a perception study to investigate whether other affective states involving low physiological arousal, such as sleepiness and relaxation, are associated with similar acoustical features as sadness in music.

In the production study, we employ a method of adjustment to test whether participants can distinguish between eight different emotions using eight parameters to create music-like sequences: intensity, tempo, overall pitch height, pitch range, interval size, articulation, timbre, and modality. The eight emotions that participants are instructed to create include three associated with low arousal: sadness, sleepiness, and relaxation. We predict that little difference will be found between the affective states involving low physiological arousal, but there will be a difference between the low and high arousal states. In the perception study, we present a new group of participants with the previously generated music-like stimuli and ask them to rate the degree to which each sequence represents the same eight emotions. Again, we predict that participants will rate the musical stimuli representing low physiological arousal similarly, while they nevertheless will be distinguishable from the high arousal states. If the results are as predicted, we suggest that ethological signaling theory might provide a parsimonious account for this apparent confusion.

[4B-2.3] Two sonatas walk into a bar: An attempt at an empirical investigation of humor in music

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One of the dominant theories explaining the cognitive processing of humor is incongruity theory. According to this theory, one of the factors creating humor is when incongruent elements are perceived in a pre-acquired schema. As a consequence, the greater our knowledge and familiarity with a schema, the more we will appreciate sophisticated deviance from the schema. The aim of the study was to examine structural (harmony and meter) and surface (timbre and tempo) incongruent deviations in music on funniness ratings. It was hypothesized that musicians would rate structural incongruities as funnier than non-musicians. 239 participants took part in the study (119 males, 120 females), of which 118 were non-musicians. A short segment from 4 well-known classical pieces played on piano was chosen (Mozart's symphony n. 40, Bach's minuet in G BWV Anh144, and Beethoven's Ode to Joy and Beethoven Für Elise). For each segment, 4 versions were created, with a change toward the end of the segment in either harmony (major to minor or vice versa), meter (triple to quadruple or vice versa), timbre (piano to harmonica) or tempo (a sharp acceleration). In a 4x4 design, each of 4 groups of participants heard the 4 pieces with 4 different variations. Participants were asked to rate familiarity and funniness of each piece. In general, funniness ratings for all stimuli were rather low. Analysis of variance showed no main effect of musical training. A main effect for piece, with Mozart evaluated as funnier, and a main effect for variations, with changes in timbre and tempo rated as funnier were found. An interaction between variation and musician was found, showing that musicians found changes in harmony funnier than non-musicians. Results suggest that although quantifying funniness in music in such contexts is problematic, musicians are able to appreciate deviations in structural musical features more than non-musicians.

[4B-2.4] Scaling and evaluating labeled moods, emotions, and affects according to the parametric scales of the IR-model

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Musical signals (elicitors) are intrinsically non-utilitarian, non-instrumental, intentionally purposive, agent-oriented, and self-reflexive. Elaborated into rapidly changing processes, their temporal continuity resists linguistic appraisal, such as labeling. Music can induce actual moods, affects, and emotions, but in established narrative contexts, its abstract nature also models and molds expressive affects without inducing real feelings. But in both cases, music only weakly represents the external objects, the secondary linguistic appraisals, and the meta-cognitive behavioral actions typical of full-blown emotional episodes.

Accordingly, neither affect nor emotion need function as an umbrella term for describing musical feelings. Theoretically, we may define the abstract unnameable feelings of music (those without linguistic cues) as *affects*, while restricting the word *emotions* to nameable feelings—cued expressions and mental representations that are contiguously associated with language (or allied with iconicity). Thus reformulating the basic concepts of affective science, we may hypothesize a meta-scale of musical feeling, from weak *moods* to stronger *emotions* (both generating appropriately concrete linguistic cues), to even stronger, abstract *affects* (with no linguistic cues), and finally to the strongest feelings of all, *mood* plus *emotion* plus *affect* (i.e., concrete linguistic cues subtended by unnameable abstract feelings). Such scaling avoids confusing the real world of feelings with its virtual-world counterpart in music.

Likewise, we may theorize complex musical moods, emotions, and affects as emanating directly from parametric scales that define contextual congruence (positively correlated, functionally synergetic matches) and noncongruence (negatively correlated, functionally dissociative mismatches). This is in contrast to the profiled, paralinguistic appraisals of emotion where classical theories of perceptual match and mismatch all but disappear.

The IR-model thus offers a unified psychological approach where either experienced or symbolized feelings are caused by both singular and aggregated implications, realizations, and denials with respect to parametric congruencies and non-congruencies. Moreover, analyzing the components of music as inductive of both feelings and their representations is philosophically constitutive and thus supports the paralinguistic predications concerning the descriptive appraisal profiles of instrumental music.

[4B-3.1] Measuring musical engagement through expressive movement and EEG brain dynamics

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A natural method for monitoring listener engagement without distracting the listener could contribute to music perception and education research with possible wider applications to music classification, technology, and therapy. Music listeners often use words and/or gestures to describe music they enjoy. In addition to describing the music using genre or style categories ('jazz'), they may use emotion words ('happy') and words related to physical movements ('bouncy'). They may also use rhythmic hand gestures to convey the feeling and rhythmic pulse of the music. Similar gestures are used by instrumentalists during performance to focus their expressive intent. We are testing the use of expressive gestures to study musical engagement, by which we mean the experience of 'entering into' heard or performed music, a condition in which the listener perceives the musical stimulation affectively while withdrawing his or her attention from extra-musical stimuli and concerns. We trained expert and non-expert participants to communicate the feeling of music they are hearing using simple rhythmic U-shaped hand/arm 'conducting' gestures that animate the 2-D movement of a spot of light on a video display while we used body motion capture and EEG to record their movements and brain activity. The animation is intended to focus and simplify the conductor's movements. We then asked viewers to rate the recorded 2-D spot animations of the recorded gestures on a musical emotion rating scale to test to what extent the musical affective experience of the 'conductors' can be conveyed by these animations to viewers who do not hear the music. Ratings of conductor and viewer groups were well correlated, verifying that the affective intent of the conductors' gestures can be indeed experienced by viewers. We then analyzed conductors' movement and EEG data to find movement and brain dynamic patterns supporting the expression of musical feeling.

[4B-3.2] Interaction of sensorimotor and pitch-based influences on melody recognition: Evidence from event-related potentials

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Previous research has demonstrated a production effect in memory for melodies: Pitches in melodies that have been previously performed are remembered better than those in melodies that have only been perceived, and lead to amplified N2 event-related potential (ERP) responses (Mathias, Palmer, Perrin, & Tillmann, 2012). The current study extended this finding by testing how violations of pitch expectations interact with memories encoded by sensorimotor production during subsequent auditory recognition. Behavioral measures of auditory recognition memory and ERP responses to expectancy violations were utilized. Twenty pianists learned novel melodies in one of two modalities: performance (with perceived auditory feedback) or perception alone. They then listened to the melodies with or without single pitch changes, which they recognized as altered from or identical to the original melodies. Altered pitches were always nondiatonic, and therefore deviated from the melodic context both in terms of key and frequency of occurrence. Following learning, pianists showed high accuracy in recognizing altered and original melodies. Altered pitches elicited early (N1) and later (N2) ERP components. The N2 was sensitive to both learning modality and nondiatonicity; N2 amplitudes were larger for pitches in previously-produced than in perceived-only melodies, and larger for nondiatonic pitches compared to original pitches. More accurate identification of produced melodies correlated with increased N2 amplitudes. N1 amplitudes were sensitive only to nondiatonicity and correlated with a measure of sensory consonance (Malmberg, 1918); nondiatonic pitches elicited larger N1 amplitudes than original diatonic pitches. Therefore, learning modality and nondiatonicity (which combined violations of both sensory memory and schematic tonal memory) influenced pitch processing during melody recognition, but along different timecourses. Nondiatonicity affected processing at early sensory and later cognitive stages, whereas learning modality affected processing only at cognitive stages. These findings provide new evidence for low-level sensory and higher-level, production-based influences during melody recognition.

[4B-3.3] Neuromagnetic beta-band oscillation for meter processing induced by tapping to subjectively accented structure

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Musical rhythm facilitates synchronized body movements and schema-based, predictive timing perception. Our previous magnetoencephalography (MEG) study demonstrated that when a different musical meter such as a march or waltz (every 2nd or 3rd beat accented) is subjectively induced by finger tapping to isochronous unaccent auditory beats, the broadband evoked response from auditory cortex differentiates the metric conditions despite the identical auditory input (Fujioka et al., 2010). However, beta-band oscillation, which follows the tempo of the meter in a predictive manner, more strongly differentiated metric context in the left compared to right auditory cortex.

Here we examined whether meter is more strongly encoded in the left hemisphere or whether this laterality effect was due to use of the right index finger for tapping. We recorded MEG in blocks where participants performed finger-tapping with either the left or right index finger. We analyzed source activities in the bilateral auditory and sensorimotor cortices using equivalent current dipole estimates and source space projection. We found similar modulation of the beta-band activity bilaterally, but it was somewhat stronger in the side contralateral to the tapping finger. This suggests that rhythmic movement could help sustain a subjective metric representation most strong in the contralateral hemisphere.

[4B-3.4] Playing it by ear, up and down the keyboard: An fMRI study

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Next to the manifestation of sensorimotor transformations such as singing and dancing, the ability to play an instrument by ear must rely on a unique convergence of cerebral functions involving motor preparation and auditory perception. In this study, we aimed to gain insight into the extent to which auditory perception is used to activate cerebral regions implicated in bimanual keyboard performance.

Cerebral activations were studied first in 12 improvising organists (IMP) and 12 musically-unskilled controls (CTRL) while listening to two-part 'inventions.' Subjects listened to 24 familiar and 24 unfamiliar excerpts. In two tasks, they were instructed either to imagine performing the excerpt (IMAG), or to judge its performance (JUDG). In a sparse-sampling paradigm, 3T fMRI was used to measure group- , task- , and familiarity-induced BOLD response.

Comparing IMP to CTRL revealed bilateral activation of auditory and ventral PMC during IMAG *and* JUDG, regardless of familiarity, but no significant activation of left parietal cortex. Significant activations were found in right anterior parietal cortex and, during IMAG, posterior superior parietal. Masking IMAG by JUDG revealed extensive, exclusively right-hemisphere, activations, including dorsal en ventral PMC, posterior superior and anterior parietal cortex.

Subsequently, IMP were compared to non-improvising pianists (NON) revealing significant activation of right auditory cortex and SMA in both tasks. Within-group comparison of IMAG to JUDG revealed significant right-hemisphere parietal activations in IMP, contrasted with solely left-hemisphere parietal activations in NON. Again, masking IMAG by JUDG revealed significant right-hemisphere activation of superior posterior parietal cortex as a characteristic group difference.

The right-lateralized parietal activations found in IMP in this study, are possibly a manifestation of mental rotation from vertical pitch space to horizontal keyboard space. Robust, task-independent auditory activations suggest bottom-up processing of music, particularly in IMP. Bilateral activation of ventral PMC suggests a role for the mirror neuron system.

[4B-4.1] Musical training strengthens the subcortical-cortical encoding and categorical perception of speech

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There is increasing evidence suggesting that musical training alters the psychophysiological processing of complex sound, including speech. Given that speech sounds are typically perceived in a categorical manner, we reasoned that musicianship might also enhance the categorization/classification of speech and corresponding phonemic-level neural representations. To this end, we compared cortical and brainstem event-related potentials (ERPs) elicited by a speech sound continuum in musician and nonmusician listeners. Behaviorally, musicians obtained steeper identification functions and classified speech sounds more rapidly (i.e., shorter reaction times) than their nonmusician counterparts. Analysis of the underlying neuroelectric activity revealed that relative to nonmusicians, musicians showed more robust and coherent phase-locking to speech formant energy in brainstem ERPs coupled with complementary increased magnitude (N1-P2 component) in cortical evoked responses. Identification functions derived from cortical potentials showed that neuronal activity could accurately predict listeners' perceptual boundary and phonetic classification of the speech continuum for both groups. While neural indices (e.g., magnitude) extracted from brainstem and cortical ERPs were correlated with behavioral measures across the board, these brain-behavior associations were generally stronger in musically trained individuals. Results suggest that in addition to enhancing the overall salience of speech encoding at multiple tiers of the auditory pathway, musical training strengthens the coordination of processing between sensory and perceptual levels of the auditory brain. We infer that extensive musical training acts to refine a hierarchy of internalized representations for auditory objects thus supplying more faithful phonemic templates to the decision processes subserving speech sound identification.

[4B-4.2] On the bidirectionality of music-to-language transfer effects

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Psychophysiological evidence suggests that music and language are intimately coupled such that experience/training in one domain may influence cognitive processing in the other. While music-to-language transfer effects are well-documented, a demonstration of unequivocal transfer in the complementary direction, i.e., language- to-music, has yet to be established. Here, we compare the effects of musical training and native tone language experience (Cantonese) on aspects of auditory pitch acuity, music perception, and general cognitive ability (e.g., fluid intelligence, working memory). While musicians demonstrated superior performance on all auditory measures, comparable perceptual enhancements were observed for Cantonese listeners, relative to English-speaking nonmusicians, indicating a transfer from specific linguistic experience to music listening. Musicians and tone language listeners also showed evidence for improved working memory capacity relative to nonmusician controls, suggesting that in addition to basic perceptual enhancements, language and music experience also benefit general cognitive abilities. Our findings support the notion that music and language expertise similarly tune cognitive mechanisms necessary for basic auditory as well as complex music perception and demonstrate the bidirectionality in transfer between music- and language-related processing. Ongoing event-related potential research by our group is examining the neural responses underlying these behavioral findings.

[4B-4.3] Rhythmic perception and entrainment in 5-year-old children: Temporal accuracy at four isochronous rates and its impact on phonological awareness and reading development

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Since music and language have parallel auditory perceptual mechanisms research has sought to link the two together, often suggesting that an increase in exposure to one might lead to improvements in the other. It has been suggested that increased exposure to music is causal in improving early literacy skills. However I argue that it is the rhythmic and metrical pulse rate of the music, rather than the many other aspects of music that engage the young child so readily, that is the key link for parallel processing in both domains. Indeed the research presented shows that a programme of rhythmic speech, or chants, can be more effective than a programme of music and songs in improving a 5-year-old child's phonological awareness skills, especially if they are presented at a pulse rate of 500ms.

The data presented is interpreted with respect to a theoretical framework linking music and language based on temporal sampling (Goswami, 2011). Rhythmic entrainment tasks were presented in a range of musical activities, including drumming along to music and singing nursery songs and rhymes, to 192 four and five- year-old children. The musical and rhythmic activities were given in several different forms to see which would be most effective in showing the children's ability to synchronise to a beat. These were all presented at four pulse rates (400 ms, 500 ms, 666 ms, 1000 ms).

Overall, children showed greater temporal accuracy (rhythmic entrainment) in keeping time with a musical piece rather than keeping in time with a metronome. Entrainment accuracy was greatest at the 500 ms rate. Even though children were more temporally accurate when singing than in the drumming entrainment tasks, individual differences in rhythmic entrainment were linked to I.Q. There was some evidence that accuracy in synchronization to drumming, rather than singing, showed links to future word reading skills.

[4B-4.4] Nonmusical benefits of early music training

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Musical training has been shown to strengthen speech perception in the presence of background noise (e.g., Parbery-Clark, Skoe, Lam, & Kraus, 2009). Given that musicians' ability to attend to a complex auditory signal underlies perceptual acuity in challenging listening environments, we asked whether enhanced hearing-in-noise perception could be further parsed by musical aptitude or by the age at which participants began musical training. We controlled for any hearing loss in our population of 22 university students—musicians and musical amateurs—by only including individuals with pure tone audiometric thresholds below 25 dB for 0.5-4 kHz and thresholds below 30 dB for 8 kHz tones, and excluding subjects with absolute pitch. To this end we examined: i) musical aptitudes (Advanced Measures of Music Audiation or AMMA test; Gordon, 1989), ii) fine pitch discrimination in quiet and noise (Temporal Fine Structure or TFS test; Moore, 2008) and iii) hearing-in-noise abilities. The hearing-in-noise tests consisted of the standard adapative HINT test, as well as newly developed forced-choice tests using speech sentences and tone language syllables (same-different discrimination). Preliminary results show that for musicians the AMMA aptitude score was inversely related to pitch discrimination at 1.25 kHz, $p < 0.5$; high aptitude correlated with smaller thresholds of discrimination. We also found that for participants who began musical training at age 8 or younger, trends exhibited i) improved discrimination of tone-language syllables in noise and ii) improved pitch discrimination at 400 Hz. For those who began training at age 6 or younger, we found improved English sentence discrimination in noise ($p = .06$). Taken together, our findings suggest that early musical training can enhance pitch discrimination and perception of speech through noise. Further studies are underway to access hearing in noise abilities in non-musicians and tone-language speakers.

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