Schedule: June 16

1:00 – 7:00 pm
Registration
Moyer Student Union

3:30 – 5:30 pm
Welcoming Addresses and Keynote by Richard Ashley
Moyer Student Union Rooms 201 & 202

5:30 – 7:00 pm
Opening Reception
Moyer Student Union Rooms 201 & 202

Schedule: June 17

Tuesday - Recital Hall

9:30 – 10:30
Emotion
9:30 *Huron: Emotional Consequences of Expectations: A Theoretical Model with Applications*
9:50 *Leman, Vermeulen, De Voogdt, Taelman, & Moelants: Correlations between Perceived Emotive/Affective Qualities and Auditory Features of Music*
10:10 *Szpunar, Schellenberg, & Pliner: Exposure and Liking for Musical Stimuli: Associations and Dissociations with Recognition*

Break: 10:30 – 11:00

11:00 – 12:20
Popular Culture
11:00 *Gjerdingen: Social Factors in the Categorization of Genre*
11:20 *Bennett: Song Stuck in Your Thoughts? Profiling Musical Imagery Repetition (MIR)*
11:40 *Thompson & Russo: Effects of Music on the Perceived Significance of Lyrics*
12:00 *Boltz: The Cognitive Processing of Films and Musical Soundtracks*

Lunch: 12:20 – 2:30

2:30 – 3:30
Pitch
2:30 *Russo & Thompson: An Interval-Size Illusion: Extra-Pitch Influences on the Perceived Size of Melodic Intervals*
2:50 *Sonnadara & Trainor: The Octave Illusion: Experimental Evaluations of Simple Suppression and Fusion Models*
3:10 *Hall & Wieberg: Reconsiderations of a Process that Integrates the Features of Musical Tones*

Break: 3:30 – 4:00

4:00 – 5:20
Music & Brain
4:00 *Graziano & Johnson: August Knoblauch and Amusia: A Nineteenth-Century Cognitive Model of Music*
4:20 *Levitan: Musical Meaning is Processed in "Language" Areas of the Brain*
4:40 *Brown, Parsons, Martinez, Hodges, & Fox: Brain Basis of Singing, Harmonizing, Melodic Improvisation, and Language Improvisation*
5:00 *Cook, Fujisawa, & Takami: A Functional MRI Study of Harmony Perception*

Tuesday – Room 159

9:30 – 10:30
Analysis
9:30 *Rozin: A Music Perception Manifesto: How Music Analysis Can Capture Perceived Musical Structure*
9:50 *Joichi: Harmonic Paths and Grouping Structure in a Piano Prelude by Debussy*
10:10 *Secora Pearl: Hypothetical Universe: A Functionalist Critique of Lerdahl-Jackendoff*

Break: 10:30 – 11:00

11:00 – 12:20
Composition
11:00 *Kraly: Modeling Improvisation: The Generative Ability of Jeff Pressing's Model*
11:20 *Phillips & McMahan: Cognition, Creativity, and Composition: A Psychological Analysis of the Process of Composing Music*
11:40 *Wolek & Lipscomb: Understanding the Perception of Granular Processing*
12:00 *Schultz: Multiple Time Frames in Contemporary Music: Postulating a Phenomenology of Perception*

Lunch: 12:20 – 2:30

2:30 3:30
Cross Cultural
2:30 *Mavromatis: A Probabilistic Model of Melodic Process in Greek Church Chant*
2:50 *Moelants: Tempo, Meter, and the Perception of 'Aksak' Meters*
3:10 *Lantz, Kim, & Cuddy: The Influence of Tone Duration on Pitch Structure: Perception of a Korean Tonal Hierarchy*

Break: 3:30 – 4:00

4:00 – 5:20
Performance 1
4:00 *Headlam, Bartlettle, & Bocko: "Latency, Musicality, and Network Performance"*
4:20 *Lammers & Kruger: Performance Errors and Expertise*
4:40 *Woody: Distinguishing the Component Cognitive Skills of Expressive Performance*
5:00 *Morimura, Ushida, Iida, Naemura, & Harashima: Impressions of Non-vibrato Singing in Choral Music*

5:30 – 6:30
Society Business Meeting in the Recital Hall

7:00 – 9:30
Jam Session in the Recital Hall

Schedule: June 18

Wednesday – Recital Hall

9:30 - 10:30
Speech & Music
9:30 *Ashley: Categorical and Linguistic Aspects of Musical Pitch Space*
9:50 *Safari: Tritone Paradox: The Tone Language Nexus*
10:10 *Dalla Bella, Palmers, Jungers: Are Musicians Different Speakers than NonMusicians?*
Break: 10:30 – 11:00
11:00 – 12:20
Performance 2
11:00 *Narmour: Twelve Cognitive Principles for Performers: Interpretation and the Implication-Realization Model*
11:20 *Palmer & Schendel: Working Memory Constraints in Music Performance*
11:40 *Pfordresher, Palmer, Jungers: Does Planning Contribute to Speed/Accuracy Tradeoffs in Music Performance?*
12:00 *Keller& Koch: Action-Effect Compatibility in the Production of Tone Sequences*

Lunch: 12:20 – 2:30

2:30 – 3:30
Timbre
Kendall: Extending Timbre Research
Horner & Beauchamp: Discrimination of Sustained Musical Instrument Sounds Resynthesized With Randomly Altered Spectra
Hall, Blasko, Koch, Stevenson, Rowe, & Drabik: A Demonstration of Stroop-Like Interference With Instrument Timbres
Break: 3:30 – 4:00
4:00 – 5:20
Expectation
4:00 *Jones, Puente, & Moynihan: Some Influences on Low-Level Melodic Expectancies*
4:20 *Ng: Temporal Expectancy at the Level of Musical Phrases: A Study of Expectancy Length*
4:40 *Carter, Brown, & Eaglestone: A Comparison of Folk Music Analysis Using the Implication Realisation Model and GTTM*
5:00 *Margulis: A Theory of Melodic Expectation*

6:30 – 8:30
Banquet: At the Aladdin Hotel and Casino - Spice Market Buffet

Wednesday – Room 159

9:30 - 10:30
Rhythm
9:30 *Desain, Honing, & Sadakata: Predicting Rhythm Perception from Rhythm Production and Score Counts: The Bayesian Approach*
9:50 *McAuley, Jones, Holub, Miller, & Moynihan: Effects of Age and Tempo in the Timing Control of Rhythmic Performance: A Lifespan Study*
10:10 *Franek & Fabianova: Interference in Memory between Adjacent Tempi*
Break: 10:30 – 11:00
11:00 – 12:20
Computational
11:00 *Meudic: Musical Similarity in a Polyphonic Context*
11:20 *Temperley: Bayesian Models of Metrical Analysis*
11:40 *Izmiril: Spectral Distance Patterns Among Diatonic Sets: Implications for Tonality*
12:00 *Goga: An Optimization of the Aesthetic Melody Line of Computer Music*

Lunch: 12:20 – 2:30

2:30 – 3:30
Applications
2:30 *Zehnder, Igoe, & Lipscomb: Immersion Factor Sound: A Study of the Influence of Sound on the Perceptual Salience of Interactive Games*
2:50 *Lesiuk: Music and Emotion: The Effect on Work Performance of Computer Software Developers*
Break: 3:30 – 4:00
4:00 – 5:20
Listening
4:00 *Aiello, Aaronson, Balachandran, & Nadir: What is Salient When You Listen? An Evaluation of Musicians' Responses*
4:20 *Lipscomb, Kendall, Moorefield, & Tolchinsky: Immersive Sound: Does 5.1 Surround Sound Really Make a Difference in the Experience of Music Listening?*
4:40 *Kerins & Lipscomb: Study in Audience Perception of Sound Modes in Cinema*
5:00 *Davis: "Extractive Listening": Examining the Relationship between Vocalization and Memory During Melodic Dication*

Schedule: June 19

Thursday – Recital Hall

9:30 – 10:30
Development 1
9:30 *Lamont: Musical Preferences in Pre-schoolers: The Effects of Pace and Familiarity*
9:50 *Kim & Werner: Infants' Perceptions of Transposed Melodies*
10:10 *Bergeson & McCune: Mothers' Speech and Singing to Deaf Infants with Cochlear Implants: A First Report*
Break: 10:30 – 11:00
11:00 – 12:20
Development 2
11:00 *Lamont: In the Influence of Style and Tempo in Prenatal Music Exposure*
11:20 *Lisboa: Children's Understanding of Music: Procedural and Declarative Knowledge*

Thursday – Room 159

9:30 – 10:30
Posters with Authors
Break: 10:30 – 11:00
11:00 – 12:20
Posters with Authors

Posters

1) Balkwill, Thompson, & Cuddy: Acoustic Parameters of Emotive Music: A Comparison of Praat-Derived Measures of Japanese, Hindustani, and Western Music

2) Benadon: Slicing the Beat: Jazz Phrasing and the Legend of the Swinging Triplet

3) Berens & Pastore: Temporal Duration JudgmentWith a Variable Inductions Sequence

4) Bolduc & Montesinos-Gelet: Pitch Awareness and Phonological Awareness

5) Bradshaw, Jacobson, Nakamura, Donaldson, & Chapman: Effects of Music Distraction on Neurophysiological Markers for Pain

6) Brady: Perceived Metrical Accent in Musical Rhythms

7) Curtis & Bharucha: Tonal Violations Interact With Lexical Processing: Evidence From Cross-Modal Priming

8) Dale, Brunetti, Mastacchi, Londei, Olivetti Belardinelli: Are ERPs Responses to Harmonical Changes Related to Spontaneous Rhythm and Musical Intelligence?

9) Duarte & Mazzotti: The Musical Perceptive Processes on the Social Representations Approach

10) Hutchins: Harmonic Functional Categorization

11) Kim & Lipscomb: An Investigation on the Relationship between Visual and Auditory Signal

12) Kiss: The Dynamic Interpretation of the Cognitive Music Processes

13) Korsakova-Kreyn: Time-Space of Music

14) Krishnaswamy: Intervals and Intonation in South Indian Classical Music

15) Lemieux, Fisher, & Pratto: A Music-Based HIV Prevention Intervention for Urban Adolescents

16) Loginova: Problems of Music Perception and Interpretation Nowadays

17) Maria: Walking the Meter on Computer Controlled Piano Music

18) Ollen & Huron: Musical Form and Habituation Theory

19) Patel & Iverson: Verbal Symbols of Musical Sounds: An Empirical Investigation of the Relationship between Drum Sounds & Speech Syllables in North Indian Tabla Drumming

20) Popescu, Otsuka, Deliege, & Ioannides: Neural Correlates of Music Perception: A MEG Study

21) Russo, Ammirante, & Thompson: Beyond MusicTraining: Influence of Cerebral Lateralization on Musical Ability

22) Samplaski: Interval and Interval-Class Similarity: Results from a Confusion Study

23) Schulkind: Melody Identification: A Multiple Regression Approach

24) Stratton & Zalanowski: Anticipated Pleasure of Music-Based on Samples versus Memory

Session: Emotion

June 17 : 9:30 – 10:30 : Recital Hall

Chair: Simone Dalla Bella, Ohio State University

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Emotional Consequences of Expectations: A Theoretical Model with Applications

A theory of expectation is presented in which feeling states are evoked through the interaction of four separate response systems. Two systems are active in the pre-outcome epoch (i.e., feelings that occur prior to the expected event), and two addition systems are active in the post-outcome epoch. For convenience, the four systems can be dubbed "imaginative," "tension," "prediction," and "outcome."

Imagining an outcome allows us to take vicarious pleasure (or displeasure), as though the outcome has already happened. You might work overtime because you can imagine the embarrassment of having to tell your boss that a project remains incomplete. Neurological evidence for such a system is evident in patients who fail to anticipate the feelings associated with possible future outcomes (Damasio, 1994).

As the moment of an anticipated event approaches, the body prepares for both motor (arousal) and perceptual activity (attention). The goal is to match arousal and attention to the expected outcome, and to synchronize arousal and attention levels so that they are reached just prior to the event onset. Delaying the onset of the anticipated event causes arousal and attention to be sustained at higher levels than needed, leading to mild stress or tension.

An expected stimulus is more accurately perceived when it is predictable. Since accurate predictions are of real benefit to an organism, there must be psychological rewards and punishments that encourage predictive accuracy and that are independent of the hedonic value of the outcome. Psychological evidence in support of a prediction response is found in the work of Mandler (1975). Finally, emotions are evoked that reflect appraisals of the pleasantness or unpleasantness of the outcome. Such emotions act as behavioral reinforcements.

This four-system theory is applied to the analysis of music. Detailed, moment-by-moment analyses are presented for common musical devices including the suspension, anticipation, the appoggiatura, and the deceptive cadence.

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Correlations between Perceived Emotive/Affective Qualities and Auditory Features of Music

This study aimed at investigating the relationship between perceived emotive/affective qualities and acoustical properties of musical excerpts. (A) Fifteen bipolar adjectives were used to quantify the perceived emotive/affective quality of sixty different musical excerpts, taken from a variety of musical styles and genres. Analysis of the subjective evaluations of a group of hundred listeners (each evaluating twenty four excerpts) shows consistency in response strategies. Factor analysis reveals three underlying factors. The first factor (19.5% of the variance) refers to adjectives that make a distinction between favorable and unfavorable qualifications, and is thus related to the valence of the perceived qualifications. The second factor (19% of the variance) is related to power, control and aggression and is labeled as dominance. The third factor (18% of the variance) refers to the emotional involvement or arousal. (B) In a second part of the experiment, eight subjects were asked to perform the same task, now making judgments of all 60 the musical excerpts. Results were projected onto the three-dimensional space. (C) Each factor was then compared with a set of surface auditory-based acoustical features, extracted from the musical audio by means of an auditory-based computer model. The result of a stepwise multiple regression analysis shows that Factor 1 (valence) has a significant correlation with the number of onsets. Factor 2 (dominance) shows a significant correlation with the average roughness in 7 of the 8 cases. For factor 3 (arousal) only isolated effects could be found and therefore these results are not conclusive. (D) Regression analysis with manually annotated features shows that Factor 1 relates to both harmonicity and tempo, Factor 2 relates annotated loudness. The third factor, again,

shows no significant relationships. As general trends we conclude that both low-level audio features and manually annotated features correlate with perceived emotive/affective qualities of music. The higher the note onsets and/or the tempo, and/or the harmonic consonance, the more positive qualities are attributed to the music. Roughness and loudness contribute to the aggressive qualification. The method has a focus more on attribution rather than arousal.

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Exposure and Liking for Musical Stimuli: Associations and Dissociations with Recognition

We examined changes in liking and memory for musical stimuli as a function of number of previous exposures. The stimuli consisted of short tone sequences in Experiment 1, and excerpts from orchestral recordings in Experiment 2. In both experiments, the procedure consisted of three phases: exposure, liking ratings, and recognition ratings.

In Experiment 1, listeners heard 4, 16, or 64 repetitions of short tone sequences. Half of the listeners were in a focused-listening condition that required them to count the number of tones in each sequence. The other half were in an incidental-listening condition that required them to shadow a short story while the tone sequences were presented in the background. For those engaged in focused listening, number of exposures affected recognition but not liking. In the case of incidental listening, liking increased with increasing exposure but there was no evidence of recognition. These findings are consistent with proposals that the mere-exposure effect is stronger for stimuli that are not remembered explicitly. They are also consistent with the idea that emotional responding to music is independent of memory for music.

Listeners in Experiment 2 provided comparable liking and recognition ratings after hearing 2, 8, or 32 repetitions of orchestral excerpts. In the focused-listening condition, listeners were required to identify the lead instrument of each excerpt during the exposure phase. Subsequent recognition of the excerpts increased monotonically with exposure but liking ratings followed an inverted U-shaped function, with initial increases followed by decreases. Thus, in contrast to Experiment 1, a reliable effect of satiation was observed. For listeners in the incidental-listening condition (identical to Experiment 1), increasing exposure led to monotonic increases in liking accompanied by small increases in recognition. Thus, in both conditions, liking *and* recognition of these ecologically valid stimuli changed as a function of exposure.

In sum, the results indicate that (1) the ecological validity of musical stimuli has implications for the evaluative consequences of exposure, (2) associations and dissociations between liking and memory are context dependent, and (3) high levels of recognition for musical stimuli are associated with reductions in liking.

Session: Analysis

June 17 : 9:30 – 10:30 : Room 159

Chair: Eugene Narmour, Univ. of Pennsylvania

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A Music Perception Manifesto: How Music Analysis Can Capture Perceived Musical Structure

This paper presents the kernel of a new music-analytical methodology that models both the formation of perceived musical structure and the memory of that structure. Extant models of remembered musical structure ignore the vital aspects of on-line musical experience as well as how memory distorts moment-to-moment perceptions. Conversely, models of moment-to-moment perceptions tend to avoid showing how memory affects the prominence of past events during the listening process. A complete model of perceived musical structure must represent musical process, musical memory, and the constant interaction between the two.

To begin constructing such a model, I offer a new definition of musical structure, one that includes not only hierarchical rank (Narmour 1984) but also what I call "event salience," a measure of the affective impact of a note or chord (Rozin 2000). Following Narmour (1990, 1992), I represent hierarchical connections via brackets. Event salience translates into the size of a notehead; larger noteheads represent more salient events. I then argue that since any single graphical representation can only capture an individual moment (as in a photograph), an appropriate system of analysis must entail a continuously evolving graph (as in a flipbook or movie). As a piece of music progresses, the perceived structure evolves. The analytical system captures this evolution through a series of graphs that show how salience and hierarchical relationships fade in memory. Through an analysis of the opening melodic gesture from Brahms's Sonata for Cello and Piano in E Minor, Op. 38, I demonstrate a new graphical system to represent a listener's dynamic (and messy) perceptions of musical structure. Lastly, I offer a challenge to experimental psychologists to contribute vital empirical data that can direct and refine the next steps in the development of this analytical system.

References

Narmour, E. (1984). Some major theoretical problems concerning the concept of hierarchy in the analysis of tonal music. *Music Perception, 1* (2), 129-199.

Narmour, E. (1990). *The Analysis and Cognition of Basic Melodic Structures*. Chicago, IL: The University of Chicago Press.

Narmour, E. (1992). *The Analysis and Cognition of Melodic Complexity*. Chicago, IL: The University of Chicago Press.

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Harmonic Paths and Grouping Structure in a Piano Prelude by Debussy

Debussy's "La terrasse des audiences du clair de lune" presents the listener with unexpected tonal paths. This study investigated clarity of tonal implication in relation to phrase boundaries by examining listeners' experiences of local tonics in passages displaying unexpected harmonic shifts over phrase seams. The hypothesis is that the strength of tonal closure at phrase boundaries results in quicker reaction time when subjects are asked to sing the local tonic. In addition, there will be agreement among subjects on the most stable note when strong tonal implications coincide with phrase boundaries. As an additional step, a comparison to tonal predictions of the Krumhansl-Schmuckler tonal algorithm was made.

Subjects with significant musical training (graduate and upper-level undergraduates) listened to four short passages from a standard recording of the piece. Subjects heard the passages in two randomized blocks of trials. For each trial, subjects heard two versions of the passage. The first version included material up to a phrase seam. The second version included the harmony following the boundary. Subjects were asked to hum the most stable tone or local tonic for each version and trial as quickly as possible. Dependent measures included the pitch sung by the participants and reaction time. Reaction time was categorized according to the number of seconds participants took to respond. In addition, predictions from the Krumhansl-Schmuckler algorithm were derived using temporal windows of different sizes.

Results reveal that subjects hummed different pitches based on whether or not an unexpected harmony immediately followed the seam. Fewer subjects agreed upon the most stable pitch in passages with relatively weaker grouping boundaries. Reaction time was not consistently slower for those passages including the unexpected harmony; rather, longer reaction times corresponded to the diversity of pitches sung for a local tonic.

In results to date, the subversion of expected harmonic goals results in a less clear sense of tonic, particularly at phrase seams. This suggests increased cognitive load when experiencing tonal indeterminacy over phrase boundaries. In addition, human perception considers musical features that shape sense of tonality which are not captured by the algorithm.

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Hypothetical Universe: A Functionalist Critique of Lerdahl-Jackendoff

This paper presents a critique of some assumptions from generative linguistics as applied to music, and proposes alternative and complementary approaches derived from *functional* linguistics, providing a less hypothetical approach that may prove more consistent with actual lived experience. Lerdahl & Jackendoff's 1983 book "A Generative Theory of Tonal Music" (GTTM) has stood for twenty years as required reading for work at the border of music and language. However, the reliance in their theory on musical scores, rather than the sound source implicitly assumes a direct and consistent correlation between a score and a listener's perception. While this is consistent with work in generative linguistics, this assumption is not warranted, as it ignores the stage of *production* that necessarily intervenes. In short, no accommodation is made for the difference between reading music in silence and hearing a performance.

Evidence from analysis of sound examples presents systematic discrepancies between scores and performances of those works. If a cognitive theory is to describe music as it is experienced, it is essential to accommodate these discrepancies. While experiments can and have exploited computer-generated sound in precise relationship to the score, this approach fails to acknowledge that surface variation in the sound is an inherent part of the normal human experience of music.

While the methodological choice in GTTM of seeking to describe end-state analyses rather than on-line temporal processing is noted, such a choice limits the scope and relevance of the theory. In relying heavily on written documents rather than sound objects, this theory becomes more a tool for understanding analytical and interpretive intuitions than a cognitive theory of sound perception. The current paper shows how acoustical analyses of various performances create problems for the hypothesized "experienced listener," rendering a theoretical framework based on readings from a score suspect. The musical examples are drawn directly from those in GTTM.

While the strength and value of experimental approaches is acknowledged, analysis from real-life examples can supplement and enrich experimentalism, and provide a needed counterbalance to a purely experimental tack.

Session: Popular Culture

June 17 : 11:00 – 12:20 : Recital Hall

Chair: Daniel J. Levitin, McGill University

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Social Factors in the Categorization of Genre

Current projects in the machine categorization of popular genres (e.g., Tzanetakis, 2002) have achieved impressive results in the range of 60-70% correct, where "correct" is defined as matching either human judgments or the consensus categorizations of the music industry. If 60-70% of genre classification can be achieved by a machine analysis of short-time-frame psycho-acoustical features, or by humans in fractions of a second (e.g., Perrot & Gjerdingen, 1999), then a reasonable inference may be that timbre is a main effect in the categorization of genre. The timbre of a loud, distorted electric guitar, for instance, is a cue to various Rock genres, just as the sound of claves or a guiro is a cue to various Latin American genres. Humans, of course, do not fully agree on the exact boundaries for such categorizations, and may object strongly to what they perceive to be a "wrong" categorization. The timbre of a distorted guitar, for example, can indicate both "Arena Rock," a mass-market lowbrow genre, and "Indie Rock," a niche market favored by college students. These two genres are socially antithetical. It is thus possible that 30-40% of the categorization of genre by an individual is based on personal and/or social categorizations tied to other musical and extra-musical factors (lyrics, dialect, artist images, social associations, etc.). The close connections between popular genres and social groups, and the close connections between popular genres and the formation of a personal identity among young people make this a fruitful area for research. The presentation will explore some currently contested music-categorical boundaries in the North American music landscape and relate the issue therein to theories of social categorization (e.g., McGarty, 1999). In particular, the selection and exploration of a preferred music genre in a person's teens and twenties will affect their categorizations of later musical styles as they age. Many of these issues have import for commercial interests, not only in the music industry itself, but also for advertisers and other media sources.

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Song Stuck in Your Thoughts? Profiling Musical Imagery Repetition (MIR)

This paper coins the term "Musical Imagery Repetition" (MIR) to define the universal phenomenon of music getting "stuck in thought." MIR is defined as previously heard music that, while consciously unintended, repeats uncontrollably and pervasively in thought. Only tangentially-related academic inquiries have considered this phenomenon before the present study.

A 51-question Internet-based survey instrument was posited by Email to 4000 individuals. 503 surveys were collected from individuals in 33 countries. Most of the numerical survey data was analyzed using simple percentage or count measurements. However, single-factor ANOVA measurements were utilized to discern differences in MIR frequency between certain sub-categories of the population. Methodological checks were conducted to demonstrate there was not a MIR-experiencing population bias among the survey respondents.

MIR was found to be universal among "internet survey answering" populations worldwide (98.2% occurrence). A chronological profile of the average MIR episode is provided including characteristics of pre-MIR, during-MIR, and post-MIR states. In addition, the ANOVA results indicate that the more musical listening or participation an individual has engaged in, the more frequently MIR occurs ($F(1, 277) = 4.86$, $p < .028$.). The younger the individual, the more likely MIR is to occur ($F(3, 276) = 6.60$, $p < .0002$.). Caucasian individuals and individuals who grew up in the United Kingdom (or currently reside there) have MIR more frequently than non-Caucasians and non-British citizens ($F(1, 233) = 3.65$, $p < .04$; $F(1, 276) = 11.34$, $p < .0000185$.). Those who tap or hum before noticing MIR have more MIR episodes than those who do not ($F(1, 263) = 13.38$, $p < .0003$.). Finally, those who describe MIR in negative terms have MIR more often than those describing it in positive terms ($F(1, 188) = 5.15$, $p < .02$). It may be that females and left-handers have MIR more than their

counterparts ($F(1, 279) = 3.23$, $p < .073$; $F(1, 279) = 3.10$, $p < .079$.). MIR frequency does not appear to be mediated by words, drug use, hyperactivity, or concentration levels immediately preceding MIR.

The results from the present study are used to suggest several hypotheses about possible functional purposes of MIR. Practical uses of extensive MIR research are also posited.

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The Attribution of Meaning to Lyrics in Music

Listeners sometimes attribute great significance to lyrics in music, even when those lyrics are banal or incomprehensible outside of a musical context. This study sought to document this phenomenon empirically. Listeners were presented with lyrics in the form of recorded song (with accompanying music), recorded speech (without accompanying music), or written poetry (text only). One group of listeners was presented with spoken lyrics and written poetry, and another group of listeners was presented with sung lyrics and written poetry. The lyrics presented to the two groups was the same, were spoken or sung by the same performer, and were equated for overall duration and loudness. The written poetry thus served as a common anchor against which the spoken or sung lyrics could be compared. The meaningfulness of lyrics was judged using a likert-type scale. Listeners were told that a high rating of meaningfulness implied that the lyrics were powerful, suggestive and generative of associations. Lyrics embedded in songs were judged to be significantly more meaningful than spoken lyrics. We propose that judgments of meaningfulness of lyrics in a musical context are susceptible to misattribution errors. That is, emotional and syntactic properties of music are powerfully suggestive of meaning, and act to enhance the perceived meaningfulness of accompanying words.

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The Cognitive Processing of Films and Musical Soundtracks

Musical soundtracks are an integral dimension of most cinematographic productions and research has demonstrated that these soundtracks can influence the cognitive processing of filmed events in a variety of ways. In addition to enhancing the emotional impact of a scene, music can also influence its overall memorability as well as the interpretation of characters' motivations and actions, and the attentional salience of certain objects. These effects in turn raise the issue of how musical soundtracks are encoded and represented in memory relative to their accompanying visual scenes. One possibility is that both dimensions are jointly encoded into the cognitive system such that attending to one leads to an incidental encoding of the other, which thereby results in an integrated code. If true, then attending to music should also lead to the encoding of film information (and vice versa) and no decrement in memory performance should occur if both dimensions are attended to at once. A second possibility is that music and film are encoded independently of one another. This suggests that a given dimension will only be well remembered if it was selectively attended to at the time of encoding and performance should decline if attention is divided among both dimensions at once.

These ideas were investigated by presenting subjects with 12 film clips, each approximately 3-5 mins in duration. In one group, the mood of the accompanying music was congruent with that of the scene's ending (i.e. pos-pos; neg-neg) while in a second condition, the mood of the music and film's end were incongruent with one another (i.e. pos-neg; neg-pos). Selective attending was also manipulated in that different groups of subjects were instructed they would later be tested on the musical soundtrack; the visual scene; or both music and film. During an initial presentation phase, subjects viewed the set of film clips while rating each on a series of bi-polar mood adjectives. Immediately following this, subjects were then asked to perform three types of memory tasks: tune recognition; the recall of all film clips; and tune/film recognition, which required subjects to decide whether a given tune had been paired with a particular film clip. Results indicated that music and film can be

encoded in either an independent or unified fashion but depend on the variable of mood congruency. These findings in turn have implications for memory models of audiovisual information.

Session: Composition

June 17 : 11:00 – 12:20 : Room 159

Chair: Scott Lipscomb, Northwestern University

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Modeling Improvisation: The Generative Ability of Jeff Pressing's Model

This presentation outlines a project testing the generative ability of a cognitive model of musical improvisation presented by Jeff Pressing (in his chapter in Generative Processes in Music, 1988). The model attempts to describe the way in which an improvising musician makes musical decisions--that is, how the musician decides what to play and how to play it. Pressing's model requires that one take into consideration the performer's musical vocabulary, technical considerations brought about by the type of instrument being played (saxophone, trumpet, drums, etc.) and also the musical context: what the other musicians in the group are playing, the genre of music and the basic rules that go along with it, and other such factors. By demonstrating that these factors influence the musical choices of a performer, Pressing's model presents a very plausible case for the type of processes underlying creative or improvised behavior.

The project tests whether or not Pressing's model can result in technically and stylistically appropriate improvisations. Since the author is a jazz bassist, the model is being used to create jazz bass lines. The project creates a representative vocabulary, designs a musical context, and then applies the model to generate some bass lines. The vocabulary was created from transcriptions of Paul Chambers' bass lines; Chambers played extensively in the 1950s and 1960s, most notably with Miles Davis. All of the transcribed bass lines come from 12-bar blues tunes from the late 1950s and early 60s, thus defining the musical context within a type of song and a coherent style. Finally, the project compares these artificially generated lines with real ones to examine the success of the model in creating a characteristic improvisation. This will be achieved by presenting the generated bass lines, in both written and aural formats, to expert jazz musicians who will provide commentary and criticism. Rough analysis of the generated bass lines seems to indicate that our listeners' impressions of the lines may be dependent on whether priority was given to the underlying harmonic structure or to creating a smooth contour ("voice leading") when putting the bass lines together from raw vocabulary units.

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Cognition, Creativity, and Composition: A Psychological Analysis of the Process of Composing Music

This paper presents a content analysis performed by the first author (WDP) of the psychological processes and strategies employed by the composer who is the second author (RYM). The composer did his work while being videotaped at his desk. He verbalized his thoughts, ideas, and strategies for the taping, and his manuscript, hands, and work tools were visible to the camera. The protocols were analyzed by the first author (WDP) who is a cognitive psychologist and a musician.

The composer writes atonal music, and one of his most important tools is a chart he creates on two pages of manuscript paper. The chart consists of the original tone series, its retrograde form, its inverted form, a retrograde version of the inverted form, and transpositions of all of these into series beginning with all possible starting notes. He composes at a desk, writing notes on his manuscript and adjusting the notes based on the immediate context, global structure, and intent of the piece. He typically completes about four measures of music in a one-hour session.

The psychological processes he employs are best described as making decisions. His work is usually methodical and structured. About 10% his time is spent in quiet thought. Another 10% is devoted to thinking and talking about the overall structure and intent of the music. About 40% of his time is given to "first-pass" decision-making. This activity consists of choosing tones from his two-page chart, sketching potential melodic lines, and assessing these choices. His primary judgment criteria are pantonality, desired melodic contour, and rhythmic and accent pattern. He invariably assesses the writing

in terms of how it sounds and how it conforms to the rules of atonal composition. He consciously decides whether, when, and by how much to violate the rules.

To the authors' knowledge, this project is the only extant analysis of a composer at work in which the entire composition process is observed and analyzed and the finished music is available. The paper presents the analysis, illustrated with views of the manuscript, and a recorded performance of excerpts from the compositions.

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Understanding the Perception of Granular Processing

Granular processing of sampled audio signals (Roads 1985; Traux 1987) is a technique that has experienced increased interest in recent years. This processing technique has origins in the work of Dennis Gabor and his concept of the *acoustical quanta* (Gabor 1947), which was developed in response to perceptual research findings. He asserted that, "it is our most elementary experience that sound has a time pattern as well as a frequency pattern (Gabor 1947, p. 591)." Although several software applications are now widely available for realizing granular processing effects (Behles, Starke & Roebel, 1998; Roads & Alexander, 1997; Rolfe & Keller 2000; van der Schoot 1999), these programs have done little to clarify the perceptual connection between interface controls and audio output, a problem that has persisted since the first computer implementation was reported twenty-five years ago (Roads, 1978). A better understanding of how the audio output is perceived is a necessary precursor to the development of a simplified interface that would require the computer "to interpret how to approximate a desired result" (Roads, 2001, p. 27).

In order to foster such an understanding, the author has conducted a series of three experiments involving stimuli generated via granular processing. Twenty participants in each experiment were asked to rate the similarity of the unique and identity pairs that existed among audio stimuli created with specific granular processing parameter settings. The author then used multidimensional scaling (Kruskal 1964a, 1964b; Shepard, 1962a, 1962b) to develop a graphical representation of the perceptual organization exhibited by participants. The selection of this evaluation method was inspired by previous applications within studies of musical timbre perception (Grey 1977; Iverson and Krumhansl, 1993; Kendall & Carterette, 1991; Wessel 1979). Its use proved very successful for the current study, producing some three-dimensional matrices with low stress ($Stress < 0.1$) and high squared correlation ($RSQ > 0.9$).

Between-subject variables relating to prior experience with electro-acoustic music are also being examined, but so far have failed to exhibit any significance ($p > 0.05$). Future plans for applying the results of this study to software design will also be discussed.

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Multiple Time Frames in Contemporary Music: Postulating a Phenomenology of Perception

Within the substance of musical time, there exist hierarchical levels of temporal perception. These levels within the materiality of music interact with our external perceptions of clock/observed time to stratify and enrich the experience of time-in-music. In compositional practice, these temporal levels are articulated by formal succession, gesture, figure, and process-gesture. The projection of a multiplicity of temporal frames in music implies that these referential vocables are in some way present such that we can draw significant meaning as to their specific location in the temporal hierarchy of the music frommoment to moment. It is possible to trace various paths of temporal perception through a piece of music by apprehending the concomitant elements of these vocables as they occur in some multi-leveled periodicity. The perception of multiple time frames in contemporary music is in practice a function of how compositional processes deal with the presentation of formal succession, gesture, figure, and process gesture in the discourse. Their processual unfolding in variant combinations gives rise to three basic temporal manifestations: striated time - a variegated and explicitly inter-referential presentation of temporal hierarchies that maintains a clear rhythm of perception on a multiplicity of levels; smooth time - an active traversal of the above parameters, freely zooming in and out of the frames of temporal reference without sense of hierarchy; or rhizogenic time - a cross-referencing of perceptual time streams such that momentary windows of meaning open up as submerged processes transpierce the simultaneously presented expressive information of the multiple material strands. These manifestations can be described as "points-of-view" on, or interpretations of multiple time frames in music and they confront us with the compositional processes by which multi-valent temporal perspectives are engaged with, and projected in a piece of music.

Session: Pitch

June 17 : 2:30 – 3:30 : Recital Hall

Chair: Mari Riess Jones, Ohio State University

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An Interval-Size Illusion: Extra-Pitch Influences on the Perceived Size of Melodic Intervals

Two experiments examined a novel illusion concerning the perceived size of melodic intervals. In Experiment 1, musically trained and untrained listeners were asked to judge the size of melodic intervals using a likert-type scale. Melodic intervals had either ascending or descending pitch direction and were either a diminished fifth (six semitones) or perfect fifth (seven semitones) in size. The spectral composition of each component tone was independently varied with tones having either low or high spectral centroid. For trained and untrained listeners, the size of a given interval was deemed largest when pitch direction was congruent with the spectral shift – that is, an ascending interval with a shift from low to high spectral centroid or a descending interval with a shift from high to low spectral centroid. The finding corroborates research that demonstrated an interaction between the perceptual attributes of pitch and timbre (Beal, 1985; Krumhansl & Iverson, 1992; Melara & Marks, 1990; Pitt, 1994; Singh & Hirsh, 1992; Warrier & Zatorre, 2002). Most listeners exhibited an illusory reversal. Specifically, a diminished fifth was deemed larger than a perfect fifth if pitch direction of the diminished fifth was congruent with its spectral shift and pitch direction of the perfect fifth was incongruent with its spectral shift. Such illusory reversals were most common for descending intervals. In Experiment 2, musically trained listeners performed matching and labeling tasks with tones that were spectrally identical to those used in Experiment 1. A high level of accuracy was revealed indicating that the timbral manipulations employed in Experiment 1 do not lead to pitch distortions. We conclude that timbre can affect the perceived size of melodic intervals without altering the individual pitches involved or the category label assigned to the pitch interval.

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Intensity Effects in the Octave Illusion

The fact that the auditory system has separate pathways for processing 'what' and 'where' information is clearly illustrated by the Octave Illusion (Deutsch, 1974): when two pure tones separated by one octave are presented simultaneously to opposite ears in a sequence where the ear receiving the higher tone reverses on each repetition, many participants report hearing a series of alternating single high and low tones, with high tones consistently in one ear and the low tones in the other. Deutsch and others have interpreted this as indicating that listeners attend only to the tones in one ear when determining what sound was presented, whereas they attend only to the location of the higher tones when determining the location of the sound. In Experiment 1, we ask participants to directly compare the illusory stimulus (ILLU) with one mimicking its most commonly reported percept (IC) and show that they are easily able to distinguish between the two, indicating that the percept elicited by the ILLU stimulus might be more complex than previously reported. In Experiment 2 we show that there is a clear difference in the perceived loudness of ILLU and IC when IC follows ILLU, but not when IC precedes ILLU. In Experiments 3 and 4, we show that this result depends on the alternation of high and low tones between the ears in an extended pattern. In Experiment 5, we show that this difference in perceived loudness disappears if the interval between the ILLU and IC stimuli is sufficiently large. Experiment 5 suggests that there is a short-term increase in gain in the auditory system when processing the ILLU stimulus, although we do not yet know whether this is a peripheral or central phenomenon. We conclude that the octave illusion is highly complex, and involves intensity as well as pitch and location effects.

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Reconsiderations of a Process that Integrates the Features of Musical Tones

It has long been claimed in the visual search literature that there is a process that integrates separately registered features in order to perceive objects. Evidence for this process comes from findings for illusory conjunctions, the perception of incorrect combinations of registered features (e.g., Treisman & Schmidt, 1982). Claims have been made for a corresponding auditory integration process for simultaneously, as well as sequentially presented features of musical tones (see Hall, Pastore, Acker, & Huang, 2000; Thompson, Hall, & Pressing, 2001). Evidence for feature integration in both modalities has depended on multinomial processing models to distinguish conjunction errors that reflect guessing, the misperception of features, and illusory conjunctions. Recently, questions have been raised concerning whether illusory conjunctions from multinomial models are simply an artifact of failing to explicitly model feature misperception (Donk, 1999; 2001).

Three experiments were conducted to address these concerns for auditory feature integration. A new paradigm permitted comparisons to be made between theoretical models that assumed illusory conjunctions, the misperception of features, or both errors regarding the degree to which these models accounted for the obtained pattern of responses. In Experiments 1 and 2, musically trained listeners identified pairs of spatially distributed tones that reflected possible combinations of two instrument timbres with two pitches. Pairs of tones were presented to opposing ears (Experiment 1), or were only slightly lateralized by interaural time disparities to determine whether the perceived distance between tones influenced the likelihood of feature binding errors (Experiment 2). Conjunction responses, reflecting the incorrect combination of features, frequently occurred, and were more common for slightly lateralized tones. Furthermore, data fits were improved by models assuming feature misperception, but not illusory conjunctions.

Experiment 3 extended this evaluation to temporally distributed stimuli by having listeners identify sequential pairs of tones defined by their combination of relative pitch and duration. Preliminary results indicate a sufficient number of conjunction responses to permit modeling comparisons with experiments involving simultaneous tones. The paradigm will be discussed as an approach for evaluating factors that contribute to the misperception of features, along with implications/reservations regarding demonstrations of feature integration from search performance.

Session: Cross Cultural

June 17 : 2:30 – 3:30 : Room 159

Chair: Laura-Lee Balkwill, Queen's University

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A Probabilistic Model of Melodic Process in Greek Church Chant

We present a probabilistic model of melodic process in modern Greek church chant. This tradition is particularly relevant to cognitive studies: during church service, chant tunes are performed from memory or improvised; this skill relies to a great extent on implicit, internalized knowledge that is passed on by example, without explicit appeal to rules. We present a model that extracts the rules of the idiom from a sample corpus of chants, pointing to mental representations of melody that underlie learning, recall, and improvisation. The model may shed light on the cognition of melody in general, and offers a case study of a cognition-driven music theoretic model.

In the first stage of our analysis, a Hidden Markov Model (HMM) was trained on a corpus of chants through a variant of the state-merging algorithm by Stolcke and Omohundro (1994), using Rissanen's (1998) Minimum Description Length principle as a termination criterion. In the second stage, the optimal HMM was analyzed; its states can be interpreted as probabilistic rules, which determine the course of melody, given its preceding melodic and textual context.

Our findings show that the melody of Greek chant is shaped by textual word stress on a small scale (phrase-shaping rules); and by textual syntactic boundaries on a large scale (phrase-succession rules). Phrase-shaping rules can be pitch-specific, characterizing formulaic beginnings and ends of phrases; or intervallic, highlighting word stress through pitch contour. Given a text, the melody is completely determined by a small number of phrase parameters, reflecting melodic choices at key _decision points. These "decisions" occur mostly unconsciously in performance; but preliminary evidence from protocol reports suggests that chanters are often aware of some decision points in the melody, and use them as "memory posts." The model thus enables a chant tune to be represented by much less information than that contained in the individual notes, significantly easing the strain imposed on the chanters memory and real-time performance, in both recall and improvisation tasks. We consider the relation of our model to previous work on mental representations of melody (Deutsch & Feroe, 1981).

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Tempo, Meter, and the Perception of ‘aksak’ Meters

The fast irregular ‘aksak’ meters found in the Balkan area form a challenge for the traditional theoretical conceptions of meter. They are usually classified as ‘asymmetric’: having a regular beat with an irregular accent structure with groups of two and three beats, but the peculiarity of ‘aksak’ meters is the high speed of their basic pulse. Listening or dancing to the music, we tend to switch the beat to the level of the irregular accents. Yet, this creates a conflict with the usual definition of the beat as ‘equally-spaced’.

To solve this conflict we studied the timing of ‘aksak’ meters and interpreted them according to a global model of the temporal organization of music. Three series of data were studied: data collected by ethnomusicologists, recordings of Bulgarian dances in ‘aksak’ meters and performances of compositions by Béla Bartók, inspired by them.

Results show that basic isochronic pulses are usually too fast to serve as the beat, while groups of two, three or four pulses do fall within the existence region of musical tempo and often even within the preferred ‘tempo-octave’. Also, the length of the overall pattern falls within the preference region of metric grouping. Thus ‘aksak’ meters can be naturally interpreted as

two, three of four-beat measures in which the beats are irregularly spaced. This seems to be incompatible with common definitions of meter and tempo. However, the analyses show that deviations from regularity in 'aksak' and in performances of Viennese waltzes and other European traditional dances, notated in a regular meter, are comparable. Furthermore the 'regular' interpretation of 'aksak' meters is enhanced by aspects of the metric microstructure. Detailed analyses show that some beats are made shorter or longer in order to obtain a larger degree of regularity.

This study is a good illustration of how findings in music psychology can solve problems in traditional music theory, and explain structures found in music outside the western classical tradition. It also shows the crucial role of tempo in the perception of metrical structure, an issue often neglected in music theory.

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The Influence of Tone Duration on Pitch Structure: Perception of a Korean Tonal Hierarchy

The current study assessed the effect of tone duration on the perception of a Korean tonal hierarchy for listeners familiar or unfamiliar with the Korean musical style. To quantify the Korean hierarchy, we relied on the durational distribution of tones in a piece of Korean court music (Nam, 1998). Our experiment employed a probe-tone technique in which a melodic context was played 12 times, each time followed by one of 12 probe tones. Participants rated the goodness-of-fit of the probe tone to the context. In the experimental condition, context tones and probe tones were the five scale tones of a Korean pentatonic scale and seven nonscale tones within the octave of the scale. Scale tones received durational emphasis; all scale tones were longer than nonscale tones. Moreover, the duration of each scale tone was based on the position of the tone in the durational distribution of the Korean music. For both familiar and unfamiliar listeners, the pattern of probe-tone ratings differentiated between scale and nonscale tones and differentiated among scale tones in accord with the duration in the context and the Korean tonal hierarchy. In the control condition, the assignment of durations to context tones was re-arranged. The distribution did not correspond to the distribution of durations in the Korean piece. In particular, for the set of control "scale" tones that received durational emphasis, no pair of tones contained the near perfect fifth of the Korean scale. Probe-tone ratings differentiated the longest tones, the set of control "scale" tones, from the shortest tones, the control "nonscale" tones. However, unlike the experimental condition, probe-tone ratings did not differentiate among the longer "scale" tones in accord with their duration in the context. Thus, perception of the tonal hierarchy in the experimental condition reflected both the influence of tone duration and, as well, sensitivity to the organization of tones within the Korean tonal hierarchy. Subtle differences in the ratings between familiar and unfamiliar listeners suggested that listeners familiar with Korean music also relied on an internalized tonal schema.

Session: Music & Brain

June 17 : 4:00 – 5:20 : Recital Hall

Chair: Lola L. Cuddy, Queen's University

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August Knoblauch and Amusia: A Nineteenth-Century Cognitive Model of Music

Early models of human cognition can be traced to nineteenth-century investigations of brain and behavior. Influential neurologists such as Wernicke, Kussmaul, and Lichtheim constructed diagrammatic models to illustrate current theories of cognition. Language was the most commonly studied cognitive function during this time; however, investigators also studied other cognitive functions, such as music and visual processing. The initial interest in non-language cognitive abilities appears to have grown out of a desire to explore the relationship between language and other cognitive abilities in patients with aphasia. In the case of music, neurologists were interested in understanding how language could be produced while singing a song text but not in spontaneous speech. These observations were not only important for helping to expand knowledge about language but also for inspiring early theories about the brain and music. While a number of nineteenth-century neurologists made observations about music abilities in aphasic patients, August Knoblauch, a German physician and anatomist, was the first to propose a diagrammatic model of music (1888/1890). He described a detailed cognitive model of music processing, hypothesized the existence of nine disorders of music production and perception, and coined the term "amusia". In his model, the perception and production of music is achieved through a complex network of interconnected centers and pathways. These pathways and centers are involved in different levels of processing: sensory processes, intermediate centers that store memories, and conceptual thought (i.e., the idea center). Thus, music could only be perceived or produced following the multi-level flow of information through the network. In particular, the fact that music interacts with the idea center (which also connects to language centers) suggests that Knoblauch considered music to be a higher-level cognitive process, similar to language. In addition, his classification of music disorders had a significant effect on subsequent descriptions of music impairments. Knoblauch's model is the earliest cognitive model of music and is largely unrecognized as an important part of the history of neurology, neuropsychology, and music cognition. This paper will outline the model as well as the music disorders, and discuss the historical significance of Knoblauch's work.

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Musical Meaning is Processed in "Language" Areas of the Brain

The neural correlates of musical meaning were investigated using functional magnetic neuroimaging (fMRI). Participants listened to classical music and scrambled versions of that same music. The scrambled versions disrupted musical structure while holding all other musical attributes constant - pitch, tonality, rhythm, loudness, and timbre. Previous experiments have studied violations of musical expectancies as a way to probe musical structure and meaning, however these designs did not break the temporal coherence - and hence the meaning - of the musical stream. We found focal activation in the pars orbitalis region (Brodmann Area 47) of the left inferior frontal cortex, a region previously closely associated with the processing of linguistic meaning in spoken and signed language. Our findings suggest that this particular region of inferior frontal cortex may be more generally responsible for processing the meaning of temporally structured stimuli in general, not just those that are linguistic.

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Brain Basis of Singing, Harmonizing, Melodic Improvisation, and Language Improvisation

To understand the brain basis of the generation of music, we report a study of the singing of melodies and harmonies, and the improvisation of melody and language. Specifically, we are studying which brain areas subserve singing and which brain areas support the generation of music, as compared with language. We used 150-water positron emission tomography to scan amateur musicians vocalizing monotonically, singing repetitions of heard melodies, singing harmonizations along with heard melodies, singing melodic improvisations, and improvising sentences.

For the monotonic vocalizing, melodic repetition, and harmonization tasks, we observed major blood flow increases in the primary and secondary auditory cortices, primary motor cortex, frontal operculum, supplementary motor area, insula, cerebellum, and basal ganglia. Melody repetition and harmonization, in addition to displaying highly similar activation profiles, produced activations in the planum polare that were not present in monotonic vocalization, thereby implicating this area in higher-level musical processing. These data provide a detailed picture of the auditory and vocal components of the human song system, as well as those neural areas involved in imitation, repetition, and the pitch-tracking processes underlying harmonization.

The melody and language improvisation tasks, where subjects generated novel completions of presented stimulus fragments, activated highly similar functional brain areas, with the language task showing a tendency toward left-sided unilaterality, and the music task showing either bilaterality or a tendency toward right-sided unilaterality. The language task showed a significant activation in the frontal operculum (BA 44) of the left hemisphere only, whereas the music task showed a bilateral activation in this region that partially overlapped that of the language task in the left hemisphere. These findings provide evidence for sharing, parallelism, and non-correspondence in the localization of music and language in the brain, and await confirmatory investigation at higher spatial/temporal resolution.

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A Functional MRI Study of Harmony Perception

Both musicians and untrained listeners can easily distinguish between resolved (major/minor) and unresolved (diminished/augmented) triads. Moreover, the bright/dark ring of major/minor chords is also evident to most listeners, even young children. It is therefore surprising that, despite the fact that interval perception has been intensively studied and the perception of the consonance/dissonance of intervals can be explained with psychophysical models, such models cannot explain even the basic facts about harmony perception. Even when the effects of upper partials are brought into consideration, the relative tension of, especially, the augmented chord cannot be explained psychophysically and is normally "explained away" as a consequence of learning, cognition, and the effects of passively absorbed musical traditions (Parncutt, 1989).

Our approach to this old problem has been to examine the perception of three-tone combinations to determine the relative influence of isolated-tone tonality, two-tone interval dissonance, and three-tone effects. Discussions of three-tone harmonies that do not rely on the concepts of traditional harmony theory are surprisingly rare, but Meyer (1956) has noted that "intervallic equivalence" is an important source of harmonic tension – whether played sequentially or simultaneously. That is, when combinations of three tones result in two intervals of equivalent magnitude (e.g., two minor thirds or two major thirds), we perceive an inherent tension in the chord. We have taken this idea and developed a psychophysical model for three-tone perception that explains the relative

tension perceived in the various triads without invoking the concepts of traditional harmony theory (Cook, 2002).

In a previous fMRI study, our concern was to distinguish between the brain activity due to interval dissonance and that due to chordal tension. We found that interval dissonance activated right parietal regions, whereas chordal tension produced prefrontal (right>left) activation. In the present study, we have tested 10 subjects on similar chords in an attempt to distinguish between the two forms of resolution, major and minor, moving from a state of chordal tension. For this purpose, we have used two-chord sequences, in which the second chord exhibited a 1-, 2- or 3-semitone increase or decrease from that of the first chord.

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Session: Performance 1

June 17 : 4:00 – 5:20 : Room 159

Chair: Caroline Palmer, Ohio State University

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Latency, Musicality, and Network Performance

We define two types of latency that occur with musical interaction: "external latency" denotes delays from physical factors of distance, usually 5-100 ms; and "internal latency" denotes delays due to expressive performance, usually 50-120 ms. In a "network performance" over the Internet (2) external latency increases due to the transmission times and network delays. To investigate we address two components of musical performance and latency: 1) what effect do larger levels of external latency have on the isochrony (timing within each part) and synchronization (timing between parts) of musicians who interact over a network; and 2) how do different levels of external latency affect the ability of players to employ the internal latencies essential to a musical performance?

In this study, participants performed a Mozart duet while placed in separate locations and connected through microphones and headphones. Performers could hear themselves in real-time and the other performer delayed. Different levels of delay (from 6-206 ms) were introduced, with both performers given the same amount of delay. The participants were asked to rate their level of musicality and to develop strategies to cope with delay conditions. Observed effects included the level of external latency on the beat length within individual parts ($p < .0001$) and on the level of synchrony between parts ($p < .0001$). Different compensating strategies produced quite different results. Participants who chose a "both compensate" strategy were more successful in maintaining tempo and synchrony than participants who chose a "leader-follower" strategy. For all participants, the latency threshold for a "musical" performance was around 56-86 ms.

We propose three factors for a definition of musicality in this context. Players must feel confident 1) with the level of external latency; 2) that if they introduce internal latency into the performance the other players will respond appropriately; and 3) that they can respond appropriately to internal latencies that other performers may introduce. This study attempts to find limits for the level of external latency that allows for a musical performance and thereby tests the practicality of real-time interactive network performance.

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Performance Errors and Expertise

Most comparisons of expert and novice performers include the hoped for observation of higher levels of performance quality (Kruger, Lammers, Stoner, Allyn, & Fuller, 1996). These differences include higher levels of musicality, better intonation, better sound, and hopefully fewer mistakes. This paper focuses on what we can learn about musical performance by examining the errors that are made by trombonists who differ in expertise. Our past research has focused on movement of the trombone slide and has compared the performances of professional and student trombone players examining muscular efficiency (Lammers, 1983), speed of motion (Kruger, Lammers, Stoner, Allyn, & Fuller, 1996), and placement of the trombone slide (Kruger, Lammers, Fuller, & Allyn, 1997). In this paper, we examine the effect of expertise, tempo demands, type of music, and movement difficulty on the likelihood of a performance error, on musicality, and the ability to recover from a movement error. Nine professional, nine part-time professional, six adult amateur performers, eleven college students, and thirteen beginning trombone players serve as subjects in this study. They were asked to play exercises, musical selections, and a random sequence of notes. An Ultrasonic Motion Detector was used to record distance, velocity, and acceleration of the trombone slide. Electrogoniometers also interfaced to a microcomputer were used to measure the relative change in the position of the elbow and the wrist in two planes. All performances were videotaped. The audio portions of these tapes were judged by music students for musicality and audible errors. Not

surprisingly, the number of errors was lowest for the professional performers. However, the effects of tempo and type of music performed on the errors produced each interacted with the effect of expertise. Less skilled performers produced fewer errors while performing musical selections than performing random sequences of notes. The opposite was true for the more skilled performers. Our discussion will focus on what this tells us about the impact of expertise on performance.

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Distinguishing the Component Cognitive Skills of Expressive Performance

Music psychologists have suggested that the aural modeling of a teacher allows aspiring student musicians to develop the necessary mental representations that support expressive performance. Two types of mental representation, goal imaging and motor production, were examined in this study. Twenty-five university musicians heard expressive piano excerpts, preceded by expressionless "deadpan" versions to use as the bases of comparison. After giving imitative performances of each expressive model, subjects indicated the perceived loudness contours of the model by drawing lines on a chart. These drawings served as indicators of subjects' goal images of the models. Subjects also attempted to give deadpan performances of the excerpts themselves. Because such performance attempts contain traces of expressive conventions, they were used to establish subjects' contextual expectations for the excerpts. A theoretical model designated "contextual goal image" consisted of the loudness data of subjects' deadpan performance attempts and their line drawings of what they perceived in the models. Correlation coefficients assessed relationships between subjects' deadpan performances, their expressive performances, their goal image line drawings, and the expressive models themselves.

Multiple regression analyses were used to explain the loudness variations in subjects' expressive performances. Results indicated that subjects' drawings of the model features explained a large proportion of the variance in performance, even when controlling for the musical context (deadpan components). This emphasizes the importance of supplementing automatically applied performance conventions with an explicit goal performance plan. In additional analyses, in which subjects were divided into high and low achievement groups based on background information, subjects' contextual goal images were correlated to both their performances and the models they heard, in an effort to pinpoint the probable source of inaccuracies in imitative performances. Although the high and low achievement groups were equivalent in their ability to generate goal images, the more advanced musicians excelled with the motor production needed to implement their goal images (i.e., leading to more accurate imitative performances). Because the groups differed in reported amounts of cumulated practice and private instruction received, it is reasonable to assume that these activities are especially critical to the development of the motor skills of expressive performance.

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Impressions of Non-vibrato Singing in Choral Music

Concerning the timbre of the singing voice, knowledge has been achieved experientially, but has not been properly examined from a theoretical approach. Previous investigations on singing have also concentrated on solo performance; very little research has been done on choral music. The current investigation was motivated by a desire to address each of these shortcomings.

Although vibrato has not been welcomed in recent choral singing because it might ruin harmony, vibrato has been used a lot in solo singing for dramatic expression. The hypothesis that non-vibrato singing is more effective to pursue attractive choral singing was tested in two experiments: a listening test and signal analysis. The listening test evaluated the impressions of non-vibrato singing in choral music using 12 pairs of opposing adjectives. The signal analysis then compared the spectral composition of sung exemplars with and without vibrato.

Results from the listening test revealed that non-vibrato singing gives such impressions as

"clear", "flat", "harmonious", "pleasant", "calm", "gentle", "smooth", "deep" and "transparent", but not "powerful" or "loud". The signal analysis further revealed significant differences in the frequency structures of singing with and without vibrato. Spectrograms of vibrato singing were blurred, while spectral peaks/components were more clearly separated in spectrograms of singing without vibrato. Furthermore, power spectral density was dull and thick with vibrato, but sharp and thin without vibrato.

When the results of both experiments are taken together, it can be assumed that sharp spectral peaks and a clearly separated spectrogram would cause the timbres to be clear, flat, or harmonious. In contrast, the higher overtones that are characteristic of singing with vibrato have stronger side waves, and those side waves can make the timbre of the singing voice thicker and stronger. The results of the current investigation therefore represent theoretical support for the currently preferred style of choral singing. In other words, whereas vibrato in choral singing is effective for producing “powerful” or “loud” timbres, non-vibrato singing is more effective for producing “clearness” or “harmony” in choral music.

Session: Speech & Music

June 18 : 9:30 – 10:30 : Recital Hall

Chair: Ani Patel, Neurosciences Institute

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Musical Pitch Space: Categorical, Continuous, and Linguistic Aspects

This paper reports on a line of work, which is aimed at understanding different aspects of the relationships between spatial cognition and musical cognition. Musicians use spatial language in many ways; one of the most prevalent of these is the mapping of the musical dimension of perceived pitch to a spatial dimension of height. This study investigated the perceptual nature of c-space (ordinal but unmetered) and p-space (ordinal and metered, but without octave equivalence). Participants in the study were upper-level undergraduate and graduate students in music, with significant levels of formal musical training (mean=18.8 years). Participants heard eleven different pitches, evenly spread over more than four octaves, each presented in three different timbres. The timbres were synthesized and represented whistle, tuba, and woodblock sounds. Each pitch was categorized verbally as to a register (low, medium low, medium, medium high, or high), and made a graphic estimation of the placement of the tone within the overall pitch range on a continuous line. Responses show that perception of even such random stimuli is ordinal, only moderately affected by timbre, and is surprisingly metric. Linear regression analysis of the graphic responses reveals a placement of pitches on a continuous scale which is is, at best, quite accurate relative to the pitches' position on the equal-tempered scale across the octaves, with r-squares ranging from 0.869 to 0.5228, $p<001$). The question of whether this accuracy is due to the large number of years of formal musical training by this group of subjects is under investigation at the time of this writing, by running the same experiment with age-matched participants without high levels of musical training. Categorization of the responses shows some evidence of systematic deviations from linearity, corresponding to a bias to separate pitches into categories of low, medium, and high. Parallels between these responses and studies in visual perception are posed.

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Tritone Paradox: The Tone Language Nexus

Previous research has shown a connection between absolute pitch (the ability to name a specific pitch in the absence of any reference) and native competence in a tone language (Deutsch, 1990). In tone languages, tone is one of the features, which determine the lexical meaning of a word. I am interested in the relationship between native competence in a tone language and the tritone paradox. Furthermore, the tritone paradox studies have shown that subjects hear two tritones (with bell-shaped spectral envelopes) as either ascending or descending depending on their linguistic backgrounds (Deutsch, 1987). The tritone paradox, in addition to its bell-shaped spectral envelopes is built on the Shepard tones that consist of only octave partials of any given tone. This characteristic of the Shepard tone gives a specific quality to the tone that makes its register (in terms of its octave) ambiguous, while the pitch class of any given tone is quite clear.
For this study, tone language was defined as speakers of any Chinese languages (Mandarin, Cantonese, and Taiwanese). My hypothesis is that the native speakers of the Chinese languages hear the two tones of the tritone paradox as ascending, whereas, native speakers as non-tone languages hear them as descending. This difference is due to the inherent differences between the Chinese languages and other non-tone languages. The design of the study is a 2x2 between-subject design, and the data is analyzed using a factorial Analysis of Variance (ANOVA).

This study was conducted in the Music Cognition and Acoustics Laboratory (MCAL) at the Department of Systematic Musicology at UCLA. The tritones used for this study were from the Musical Illusions and Paradoxes, by Diana Deutsch.

This study underlines the importance of language and culture in the way it shapes our musical understanding. The significance of this study will be in the areas of music education and pedagogy, as well as ethnomusicology.

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Are Musicians Different Speakers than Nonmusicians?

We address the role of rate or tempo as a coordinating device among producers and listeners. Tempo can influence listeners' interpretation of structural units in music and speech, and listeners display a relatively fine level of tempo discrimination for music. Previous findings have shown that musicians' choices of performed tempo are influenced by the tempi of previously heard music, and speakers' production rates are likewise influenced by the rate of previously heard sentences (Jungers, Palmer & Speer, in press). This could be due to a domain-specific communicative constraint, or a more general attentional entrainment. We tested these possibilities in a cross-domain rate priming study. Two groups of listeners, musicians (musically trained listeners with 8 years' instrumental training, range = 5-13) and nonmusicians, heard melodies and uttered sentences. At the beginning of the experiment, listeners were asked to produce 2 sentences in the absence of any rate instruction, as a measure of their preferred speech rate. On each trial, participants heard a short melody presented at a fast tempo (4.8 sec long) or at a slow tempo (9.6 sec long). After each melody, listeners uttered a short (6 to 7-word) sentence. Trials were blocked by tempo and each listener heard melodies at each tempo. Participants completed a melody recognition task at the end of the experiment, designed to assess their attention to the melodies. The results indicated that musicians' utterances that followed melodies at a fast tempo were shorter than their utterances that followed melodies at a slow tempo. Such effect was not attributable to differences in preferred speech rates or to attentional / memory differences. Nonmusicians listeners showed no differences in speech rates across musical tempo conditions. These findings suggest that musicians may speak differently than nonmusicians in the presence of music. Musically trained listeners may be more attuned to tempo, perhaps because of a need to synchronize performances among musicians. Further experiments investigate cross-domain priming from speech to music.

Session: Rhythm

June 18 : 9:30 – 10:30 : Room 159

Chair : Marilyn Boltz, Haverford College

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Predicting Rhythm Perception from Rhythm Production and Score Counts: The Bayesian Approach

In the literature various hypotheses exist about the similarity or difference between the cognitive processes of perception and performance. In the present meta-study we show that empirical results on the perception of rhythmic patterns (Desain & Honing, 2003), their production (Repp, Desain & Windsor, 2002), as well as their familiarity (Zaanen, Bod & Honing, in press), can be related using Bayes' rule. In the first two studies the participants engaged in very different tasks: in the former they judged two interval performances for their rhythmic category and in the latter they performed two note patterns. These tasks are different in nature, not in the least because in the perceptual experiment the various rhythmic categories compete for a response (several interpretations are possible), while in the production task such a category is given (in the instruction). The third study focuses on a large corpus of musical scores (5860 songs). The corpus was searched for the frequency of occurrence of the rhythmic patterns. These data served as the prior distribution of the rhythms found. In the current study we reformulated all these results in terms of probability distributions, using Bayes' rule to relate the information from these different sources. As such we can predict the perception data from the production data plus the prior probabilities retrieved from the scores. The match between this prediction and the observed perceptual data turns out to be much closer than a direct comparison between production and perception data. This suggests that the measurable characteristics of the processes for perceiving and producing simple rhythmic patterns are quite similar, once superficial task demands, like competition and familiarity, are taken into account.

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Effects of Age and Tempo in the Timing Control of Rhythmic Performance: A Lifespan Study

The aim of the present study was to examine the effects of age and tempo on the timing control of rhythmic performance. Two hundred eighty-nine individuals from Northwest and Central Ohio between the ages of 4 and 95 completed a battery of paced and un-paced rhythmic tapping tasks. Un-paced tapping tasks included measurements of spontaneous, slowest, and fastest motor tempi. Paced tapping tasks included synchronization with simple isochronous sequences, then continuation of tapping at the same tempo as accurately as possible once the sequence stopped. Stimulus sequences were comprised of brief tones and presented at a range of tempi (150 ms – 1709 ms target inter-tap-intervals). The age distribution of participants was as follows: 4 – 5 years, n = 20; 6 – 7 years, n = 18; 8 – 9 years, n = 20; 10 – 12 years, n = 19; 17 – 49 years, n = 141; 50 – 64 years, n = 31; 65 – 74 years, n = 18; 75+ years, n = 20. The results from this study reveal a shift in spontaneous motor tempo (SMT) between the ages of 7 and 8; the average SMT between the ages of 4 and 7 was approximately 300 ms between taps, doubling to approximately 600 ms between taps by the age of 8, with an increase in variability. Adults showed a similar, but less consistent, trend towards slower SMT later in life. Age influenced the range of possible tapping rates, as measured by the difference between slowest and fastest motor tempo measures. Children showed a large increase in tapping range with age, with younger children much more restricted in the tempo range of their tapping than older children. Adults show the reverse age-related trend, with younger adults able to tap significantly slower and faster than older adults. Overall, un-paced tapping measures revealed a pattern of findings consistent with the

paced-tapping measures. Children demonstrated large age-related improvements in synchronization performance, but the improvements were most pronounced at the slower tapping rates. Older adults showed overall worse synchronization performance compared with younger adults, but these decrements in performance were of a much smaller magnitude than the improvements observed with the children.

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Interference in Memory between Adjacent Tempi

Our previous research addressed the problem of short-term memory for tempo of metronomic sequences and demonstrated how the tempo memory decays as a function of duration of a retention interval and tempo zone. Present experiments examined the role of additional tempi interpolated into a retention interval. Similarly to experiments in pitch short-term-memory conducted by Deutsch (1973), it was predicted that interpolated tempi might deteriorate precision of memory recall.

In Experiment 1 participants heard a short metronomic sequence with an inter-onset interval (IOI) of 500, 600, or 700 ms (base tempo). Subsequently, a short metronomic sequence in an interpolated tempo was presented. The interpolated tempo was either equal or faster/slower to the base tempo. After the retention interval (1 or 5 sec) the participants were asked to recall the base tempo via finger tapping. There were five conditions of tempo interpolation. In Condition 1 the interpolated tempo had the same rate as the base tempo. In Condition 2/Condition 3 the interpolated tempo was twice as fast/slow as the base tempo. In Condition 4/Condition 5 the interpolated tempo was slightly (by 20%) faster/slower than the base tempo. The similar paradigm was employed in the Experiment 2, however, only three conditions of tempo interpolation were employed (Condition 1, 2, 3) in broader range of tempi - 300, 400, 500, 600, and 700 ms.

In Experiment 1 a repeated measures ANOVA revealed significant effects of condition of temporal interpolation [$F(4,28)=7.17$; $p<.000$], base tempo [$F(2,14)=31.33$; $p<.01$], and interaction between condition and base tempo [$F(8,56)=3.48$; $p<.000$]. There was no significant effect of duration of a retention interval. Compared to the control condition "continuation", interpolated temporal sequences impaired memory recall. The effect of condition of tempo interpolation in particular tempi differed. Only in Conditions 2 and 3, the effects were identical in all base tempi - the interpolated tempo, which was twice as fast as the base tempo, caused deceleration of retrieved tempo, while the interpolated tempo, which was twice as slow as the base tempo had an opposite effect. It was also found that tempo zone affected the precision of memory recall. In general, fast tempi were overshot, while slow tempi were undershot. In Experiment 2 it was found significant effects of a rate of a base tempo and interaction between base tempo $F(4,28)=5.9$; $p<.001$ and condition $F(8,56)=3.46$; $p<.001$.

The interference between base and interpolated tempi resulted in the error of memory recall of the base tempo, which had the opposite direction to the interpolated tempo - fast interpolated tempi led to a slight deceleration of recalled base tempi and vice versa. The effect of tempo zone can be understood in terms of the *interval of indifference* (Vos & Ellermann, 1989) with the most precise performance in the zone of intermediate tempi.

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Session: Performance 2

June 18 : 11:00 – 12:20 : Recital Hall

Chair: Bob Gjerdingen, Northwestern University

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Twelve Cognitive Principles for Performers

A unified theory of musical performance faces many challenges. It ought to be able to show how interpretive decisions affect the cognitions and perceptions of ordinary listeners. It ought to be able to elucidate their emotional preference for one interpretation over another. In terms of performers, it ought to be able to prescribe the best aesthetic strategies for music listeners and therefore weigh the cognitive consequences of one artistic decision over another. And for historians it ought to be able to explain psychologically why interpretive decisions stylistically change across time.

By making predictions about where musical expression is most appropriately applied in a motive, phrase, or section, the implication-realization model offers one way to go about constructing a unified theory. There are three hypotheses underlying such a cognitive theory of musical performance. (1) When exact or varied repetition occurs in the score, whether parametric (aa) or formal (AB), then expression should be minimal so as to enable listeners to learn and accurately project the continuation implied by the exact repetition. (2) When differentiation occurs in the score, whether parametric (ab) or formal (AB), then performers should maximize interpretive expression. (3) When formal return occurs in the score (ABA), then performers must take care to underscore the conformant similarity (i.e., add a minimum of differentiation and stress the similarity).

Because the implication-realization model conceives the means of musical expression as parametrically independent, and because the model scales similarity (AA) and differentiation (AB) separately in each parameter, we can logically compare and evaluate interpretations of various recorded performances of the same piece. And according to the three formalized principles listed above, we can assess the perceived, cognitive aesthetic (or lack thereof) as well as prescribe interpretive strategies for maximizing the experienced affect.

The paper will also examine types of music where invoking such a theory of performance would produce a highly mannered, perhaps objectionable, performance (e.g., in naïve pieces or when exact quotations from earlier works are heard) and where applying the principles is really not practicable (e.g., in pieces with a very fast tempo; less room exists for ab variation in ensemble pieces like quartets or orchestras than in solo music). Some speculations about why recorded interpretations change over time will be considered as well.

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Working Memory Constraints in Music Performance

How do individual performers' memory constraints influence their ability to perform? Whereas studies of expert music performance have focused on long-term memory explanations in terms of chunking (Chaffin & Imreh, 2002; Williamon & Valentine, 2002), few studies have examined the contributions of working memory to individual differences in performance. We test the melody range over which musicians can plan events at any given point during performance and compare it with individual differences in working memory, based on traditional digit span scores.

Pianists memorized short isochronous melodies and performed them from memory at different tempi. Pitch errors in the performances were detected by computer. Ordering errors (those in which an error contained a pitch intended for elsewhere in the melody) were coded in terms of the distance (in number of pitches) between the performed event and its correct (intended) location. Pitch ordering errors indicated similarity-based confusions consistent with a metrical hierarchy; events on strong beats tended to be confused with other events on strong beats. Furthermore, the distances from which ordering errors arose correlated with each performer's digit span score. An incremental planning model (Palmer & Pfordresher, in press) that predicts a broader range of planning for performers with larger working memory capacity was compared with the findings. The model's

memory parameter values for the error distances of each performer correlated positively with their digit span measures.

To evaluate whether such individual memory constraints are limited to music performance, we conducted a similar experiment with speech. Participants' memorized short sequences of nonsense syllables designed to alternate strong and weak syllable stress, and produced them from memory at different tempi. Speech ordering errors indicated similarity-based confusions consistent with the music errors: stressed syllables interchanged with other stressed syllables. Furthermore, each speaker's error distances (measured in number of syllables between interacting error elements) correlated with their digit span measures. These findings suggest that working memory constraints limit both musicians' and speakers' access to the sequence elements they can prepare during production. Individual differences in working memory constraints may have ramifications for how musicians comprehend quickly changing structural relationships in music.

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Does Planning Contribute to Speed/Accuracy Tradeoffs in Music Performance?

Speed/accuracy tradeoffs are commonly found in research on human performance: accuracy on a given task worsens as the rate of production increases. These studies have typically examined simple behaviors, like contacting a spatial target with a stylus, and explanations have often focused on perceptual/motor adjustments in space (e.g., Meyer, Smith, Kornblum, Abrams & Wright, 1990). Piano performance also requires contact with spatial targets. However, music performers must plan a series of actions in advance through complex memory representations, or plans (Galanter, & Pribram, 1960; Lahsley, 1951; Miller,). We investigate patterns of speed/accuracy tradeoffs in music performance, and whether these tradeoffs reflect the use of cognitive plans.

The current research extends the range model of planning (Palmer & Pfordresher, in press) to explain error rates at different tempi in music performance. The range model characterizes planning as an incremental process in which subsets of sequence events in memory gain accessibility over time during a performance. Increases in tempo constrain the overall scope of planning in the range model, such that accessible events originate from closer distances to the current event at faster production rates. We explored whether decreased scope of planning at faster tempi would predict increases in error rates.

We report new data from an experiment in which pianists performed difficult, unfamiliar pieces; each piece was performed at 8 different tempi. Planning scope was indexed in analyses of serial ordering errors (errors in which the performer produces an event intended for a different sequence position) by measuring the distance between the current event and its intended location. Results verified the presence of speed/accuracy tradeoffs: error rates increased with tempo. More important, error rates increased as an inverse function of planning scope, as predicted by the range model. These results support the prediction that range of planning affects overall accuracy in performance. This implies that speed/accuracy tradeoffs in music performance result from cognitive as well as perceptual/motor limitations.

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Action-Effect Compatibility in the Production of Tone Sequences

A compelling link exists between music performance and a comprehensive psychological principle known as the ideomotor theory: Conventional wisdom amongst musicians holds that superior performance quality is achieved by actively imagining the desired sound rather than merely aiming to make the appropriate motor actions on one's instrument, and ideomotor theory states that actions arise automatically through the anticipation of their sensory effects. The current study—although not directly concerned with the quality of musical performances—makes a foray into the general area by testing the hypothesis that actions are facilitated by the anticipation of their effects in the context of tone sequence production. The experimental task required participants to respond as quickly as possible to each of four colour-patch stimuli by producing a unique sequence of three taps on three vertically-aligned response plates. Each tap on a different plate triggered a tone of distinct pitch: F (349 Hz), G (392 Hz), or A (440 Hz). Tones were presented in a marimba timbre, characterized by a sharp attack and rapid decay. To investigate the role of effect (tone sequence) anticipation on action (tap sequence) production, action-effect compatibility was manipulated by varying the plate-to-tone mapping. In a compatible condition, taps on the top, middle, and bottom plate triggered tones of high (A), medium (G), and low (F) pitch, respectively. This plate-to-tone mapping was scrambled differently in two incompatible conditions. Dependent variables were accuracy and response time; the latter having several components including latency (time taken to lift the tapping finger from a home key following stimulus onset) and movement time (time taken to complete the tap sequence). Results indicate that sequence production was interfered with by incompatible, relative to compatible, mappings. This effect was observed only in latencies, which were longest for incompatible mappings, suggesting that action planning was affected more so than actual action execution. The implications of this line of research are broad, covering musical interface design, the concept of pitch height, and the role of auditory imagery in music performance.

Session: Computational

June 18 : 11:00 – 12:20 : Room 159

Chair: Roger Kendall, UCLA

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"Musical Similarity in a Polyphonic Context"

In the context of pattern extraction from polyphonic music, we challenge approaches for computing the similarity between two musical sequences that model neither temporal context nor expectancy. Since both of these notions might play a role in our perception of musical patterns, the current study was conducted to investigate the limits of a system that ignores them.

The study relied on a new representation of the polyphonic musical sequence that is quantified in equally spaced beat-segments, as well as on a new definition of the notion of similarity in a polyphonic context. This approach agrees with other research (Hofman-Engl, 2002; Toivainen et al., 2002) in assuming that text-matching methods or pure mathematical algorithms are not directly convenient for music analysis. Rather it was assumed that similarity relationships between musical sequences are the result of a cognitive process that implies to evaluate the algorithms in terms of their cognitive relevance. The current approach considers three different sets of features at both global (statistical) and local levels: pitches (chords, pitch intervals), pitch contours (contours at the top and at the bottom of the polyphony) and rhythm. For each set, a similarity value is computed. The global similarity value results from the linear combination of the three feature values. Given a set of features, the similarity computation observes three important cognitive rules: it is non-transitive, non-symmetric, and non-linear. In the computation, different strategies are used according to the considered features (for instance, the similarity between chords relies on principles inspired from the set-theory). Both abstract considerations (e.g., these sequences contain many repetitions) and more physical considerations (e.g., these sequences share the same contour) were made to compute similarity. The algorithm was tested on several pieces of music, revealing that patterns can be extracted from music sequences without considering temporal context. The obtained findings also raise new questions for the notion of similarity. This research is part of the European project Cuidado.

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Bayesian modeling can be viewed as a way of inferring a structure from a surface: Bayes' theorem shows that the probability of a structure given a surface, p(structure | surface), is proportional to p(structure) p(surface | structure). The most probable structure is therefore the one that maximizes this expression.

This paper examines some possibilities and problems for Bayesian modeling in the area of metrical analysis. We can conceive of the structure as a framework of beats, and the surface as a pattern of notes. The probability of a beat pattern is determined by how regular it is, and the probability of a note pattern given a beat pattern is determined by the degree to which note-onsets coincide with beats (especially strong beats). This basic approach is reflected in the preference-rule model of Temperley & Sleator (1999) - which I will argue is essentially equivalent to a Bayesian model, though it was not conceived as one - as well as the model of Cemgil et al. (2000; 2001).

I will examine a challenge for Bayesian models of meter: the note-onset status of beats (whether or not a note occurs there) is not independent of context. A note-onset not closely followed by another note is much more likely to occur on a strong beat than a weak one. This has traditionally been captured by the generalization that longer notes are more likely to occur on stronger beats, but this idea is difficult to incorporate into a Bayesian framework. I will propose an alternative solution to this problem, based on the idea of "metrical anchoring", which incorporates the factor of note length in an indirect way. (These ideas will be demonstrated using a simple generative model of rhythmic patterns. A Bayesian meter-finding model along the lines proposed above can be used to produce novel rhythmic surfaces, by stochastically generating structures, and then surfaces from the structures, using the parameters of the model. The model can then be judged according to the naturalness or

"grammaticality" of the rhythms generated.)

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Spectral Distance Patterns among Diatonic Sets: Implications for Tonality

Models of tonality induction, tonality perception and key finding that utilize symbolic input as well as those that use audio data have been proposed in literature. The aim of the work presented is to study the geometric relationship of key distances that arises when spectra of diatonic sets are used with real instrument sounds, and compare the conformance of this relationship to music theory. Using a structural approach to tonality, the model is shown to establish a circle of fifths arrangement of keys as a result of dimensionality reduction. The model operates on sets of single-note sounds either sampled from real musical instruments or synthetically generated. Diatonic collections of these sounds are used to form spectral prototypes. A visualization of the respective distances in a lower dimensional space is obtained using principle component analysis (PCA). The projections of data on the first two dimensions are plotted to obtain a geometric representation of spectral distances among the prototypes. Using piano sounds and the major scale, the output formed a nearly perfect circle of fifths arrangement of keys. A similar result was obtained for violin sounds. The model was also tested on synthetically generated spectra by varying the number of partials, the level of harmonicity, stretching of partial frequencies and rates of spectral envelope decay. Next, the major scale was systematically altered, and in most cases, omitting tones of the diatonic set or adding extra chromatic tones lead to a collapse of the circular pattern. Third, incorporation of Krumhansl's and Temperley's tone-profile weights lead to distortion of radial and angular distances, although still maintaining an acceptable order. Forth, the harmonic minor scale was incorporated into the model, retaining the major scale. For the piano and violin sounds the minor keys formed a concentric smaller circle with respect to the circle of fifths for major keys. Results suggest that spectral patterns in diatonic sets carry distinct information regarding their corresponding keys and suggests that the human key inference might be mediated by a similar mechanism. One shortcoming of the model is that it does not address parallel minor relationships.

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An Optimization of the Aesthetic Melody Line of the Computer Music

The improvement of the aesthetic of the melody line of the music generated by a computer presents a big challenge for the scientific world. There are programs and mathematic theory (Jackendoff & Lerdahl, 1996) for computer music generation. Usually, this music is produced in conformance with the laws of harmony. However, when a computer scientist gives a musician computer-generated music, too often the musician is left thinking, "I do not want only music, which is harmonically good, but also music that sounds good". On the other hand, for a mathematician, the harmonic laws for computer music generation still leave a lot of freedom for note generation, and consequently there is a very large number of possible solutions (for a simple leading melody).

The research presented in this paper suggests a solution to the problems mentioned above. In the primary experiment a tool for music generation was created that implements the laws of classical harmony. Some simple melodies for the bass were generated, along with all possible solutions for the tenor, alto and soprano, which were then analyzed from aesthetic and classical musical form points of view. Finally, a set of rules were derived from the analysis to improve the aesthetic of the melody lines generated by the tool.

Generated melodies were small in size (8-- 13 notes) and chains of major principal chords. Many solutions given by the comp uter were distributed in the acute register, which is almost impossible for an amateur choir to intonate. Also, some melodies did not have a musical form with a clear introductive part, culmination and ending of the musical phrase. Rather, apparent phrase culminations often appeared in the beginning of, and sometimes remained throughout, the melody movement. In many examples, the soprano voice remained on the

same notes, which does not follow either aesthetic or musical form points of view.

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Session: Timbre

June 18 : 2:30 – 3:30 : Recital Hall

Chair: Frank Russo, University of Toronto

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Extending Timbre Research

Our understanding of musical timbre comes from decades of research largely focused on single pitch chroma in the area of Eb4. Recently, I have carried out a series of experiments aimed at extending timbre research across the playing range of a number of orchestral instruments, including clarinet, flute, violin, trumpet, various saxophones, French horn, oboe (ca. F4-Bb6). In acoustical analysis, the spectral centroid of the long-time-average spectrum is mapped to the diatonic pitch chroma series based on Bb4. We and other researchers have found a very strong mapping of spectral centroid to perception of timbre at ca. Bb4 (r = .90+). However, acoustical analysis at higher pitch chromas demonstrates a convergence of centroid values. I present for the first time completed perceptual data of identification and similarity, analyzed using multidimensional scaling, at increasing pitch heights. For timbre combinations, the few studies available only deal with dyads. Therefore, the timbre of triads of three chroma, orchestrated in combinations of two instruments, is evaluated acoustically and perceptually with the goal of understanding the interaction of timbre with musical consonance and dissonance.

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Discrimination of Sustained Musical Instrument Sounds Resynthesized with Randomly Altered Spectra

Musical instruments can be identified even when their spectra have been substantially altered. A trumpet is recognizable when performed in a vast cathedral or small bathroom, played through a 3D surround system or cheap PC speakers, or modified in various ways through a spectrum equalizer. These modifications, while noticeable, are easily tolerated unless perhaps large resonances occur.

How much variance can be tolerated? If a spectrum equalizer is used to modify a sound with its levels set at random, at what level would a listener begin to distinguish the modified from the original sound? At what level would it no longer be identified as a sound produced by the original instrument or type of instrument?

In the present study, we sought to determine the extent to which different degrees of random spectrum alteration can affect the perception of synthesized sustained sounds. We measured listener discrimination between eight reference musical instrument sounds (bassoon, clarinet, flute, horn, oboe, saxophone, trumpet and violin) and 50 altered versions of each. With various amounts of random spectrum alteration applied to this data, sounds were resynthesized with relative errors of 8, 16, 24, 32, and 48%. Moreover, the peak centroids of the randomly altered sounds were equalized to those of the originals. Listeners were asked to discriminate the randomly altered sounds from reference sounds resynthesized from the original data.

In all eight instruments, there was a clear monotonic increasing relationship between discrimination and the amount of random spectrum alteration. Discrimination was very good for 32 – 48% errors, moderate for 16 – 24% errors, and poor for 8% errors. The discrimination data was relatively unaffected by the musical training of the listeners and was only slightly affected by the instrument sound itself. What was perhaps most surprising was how forgiving the ear is to spectral changes made by random spectrum alteration, since discrimination was poor for sounds with up to 16% error. Sounds with 24% random alteration generate the best collection of "similar, yet different" sounds compared to the originals, while sounds with 32% errors were clearly and consistently distinguishable.

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A Demonstration of Stroop-Like Interference with Instrument Timbres

One of the most general phenomena in cognitive psychology is the "Stroop effect" (Stroop, 1935). Traditionally, in both visual and auditory demonstrations of the effect, participants are slower to report stimulus information (e.g., male gender of a voice) that conflicts with a presented word (*girl*; see Green & Barber, 1981; 1983), reflecting interference between two outputs that are related in meaning.

Recently, it has been demonstrated that visual Stroop-like interference can be obtained without verbal information, and within a single processing domain (color; Koch & Kubovy, 1996). The current investigation sought to establish whether or not similar attentional mechanisms across modalities are reflected by this non-verbal demonstration of Stroop-like interference. Four experiments were conducted using analogous auditory tasks with musical tone stimuli. In each experiment stimulus conditions included the dichotic presentation of two tones that could have the same or different instrument timbre (clarinet or violin). Listeners identified the timbre of the tone in an assigned target ear.

In Experiment 1 listeners were slower and made more errors when the timbres of the dichotic tones were incongruent relative to when their timbres were congruent. This interference effect was shown in Experiment 2 to not simply depend on spectral characteristics of the stimuli, insofar as similar levels of interference were not obtained when a contralateral distracter tone was replaced with filtered noise that shared a comparable spectral envelope. Experiment 3 further revealed that interference was obtained even when the stimuli were attenuated to significantly reduce or eliminate contralateral masking effects.

Experiment 4 examined possible relationships between this interference effect and individual difference variables, including working memory, laterality, and musicianship. Preliminary results suggest that susceptibility to attentional interference is greater for those listeners with low working memory span or less musical training. Results across experiments are taken to indicate that, as observed with visual stimuli, musical tones can be used to produce semantic, Stroop-like interference within a single domain of information. Implications for the nature of attention (and against automaticity and speed-of-processing explanations of Stroop interference) will be discussed.

Session: Applications

June 18 : 2:30 – 3:30 : Room 159

Chair: Michael Lantz, Queen's University

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Immersion Factor—Sound: A Study of the Influence of Sound on the Perceptual Salience of Interactive Games

In order to better understand the factors that lead to the success of an interactive video game, research must be conducted on the immersive factor and its constituent components. After all, the immersive factor of a game is often its greatest comparative advantage. This study will analyze the influence of sound on the immersion factor in the video game context by using stimuli excerpted from *The Lord of the Rings: the Two Towers*. As the sound design in interactive games has multiple layers, such as a musical score and sound effects, this study will primarily focus on how an individual's perception of an appropriate musical score influences the 'effectiveness' of an interactive game, and what perceptions play into the individual's judgment of the overall 'immersion factor.'

Subjects were 50 undergraduate students and 50 high school students, both male and female. All 100 subjects were asked to play 16 game stimuli, constructed by separating the musical and video layers from 4 of the original game segments, and then pairing every scene's visual with every scene's musical score (i.e., each visual layer was played four times, once with each musical score). The audio-visual clips were presented in random order on a tablet PC computer. After completing each of the 16 game segments, subjects were asked to rate the game on several bipolar adjective scales. Open-ended questions were also utilized to allow participants an opportunity to describe the experience in more detail.

Results were analyzed for within-subject as well as between-subject effects using repeated measures ANOVA. Preliminary results (n = 20) reveal that there is a highly significant difference in the interaction between ratings on the verbal scales and the control group (game w/music, game w/out music, and music only) (p =.014; F = 1.913). As a result, it does appear that there is a significant change between subject responses to the video game experience when the game play and visuals are accompanied by a musical score. Details about these differences and analysis of the full data set will be provided during the presentation.

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Music and Emotion: Effect on Work Quality of Computer Software Developers

While there are several studies investigating mood response to music, there is yet a theory or model that outlines the associations between music, mood and work performance. At least partially, the effect of music on work performance may be explained by increases in state positive affect in which creative problem solving ability is enhanced (Isen et al., 1987; Thompson, Schellenberg, & Husain, 2001). When music evokes a pleasant mood and an increased arousal state participants perform better on non-musical tasks. Thus, the support for an expected increase in creative problem solving and task performance by workers, in this case, computer systems developers.

Computer information systems design is an occupation that is very competitive, continually changing, and one that constantly requires creative approaches in software design. The trend to "downsize" or "rightsize" has been reported to lead to stress for computer developers and detrimental consequences for their design work.

Data from 56 (male=41, female=15) developers were obtained from four different Ontario companies. Data were collected in the participants' actual work environments over five weeks which encompassed a baseline of one week, followed by two weeks of music listening, followed by one week of "no music listening," and then one more week of music listening. The study design allowed for flexibility of music listening.

The results of trend analyses of variance showed Stress was highest in week four, Environmental Interference (ability to concentrate) was lowest in week four, Positive Affect was lowest in week four while Negative

Affect was highest, Quality-of-Work was lowest with no music while Time-on-Task was longest in the no music week. Narrative responses revealed the value of music listening for mood change, stress reduction, and enhanced perception on task while working. Each company projected a group culture or group personality, exhibiting differing uses of music listening in their work habits.

In consideration of the beneficial results, both in mood and quality-of-work, the researcher concludes music listening should be encouraged for the computer developers if the music listening is based on workers' choice to listen "when they want as they want."

Session: Expectation

June 18 : 4:00 – 5:20 : Recital Hall

Chair: E. Glenn Schellenberg, Univ. of Toronto

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Some Influences on Low-Level Melodic Expectancies

Some influences of dynamic expectancies in pitch space and time on pitch judgments are considered. A general theoretical context involving assumptions about a rhythmical attender is reviewed. A key aspect of this framework holds simple melodic sequences induce low-level expectancies that can be formalized as extrapolations of attention in pitch space and time. Two sets of experiments that assess implications of this approach are described. First, we describe elements of a simple (i.e. one oscillator) model of attending based on the idea of rhythmic entrainment. Next we present several experiments in which musically untrained listeners judged the pitch of target tones embedded within very simple pitch sequences. Across several experiments rate (two levels) and pitch interval structure were varied (large versus small pitch intervals); in follow-up experiments, the relative timing of the embedded target two was also varied (on-time, early, late). Listeners determined whether the target pitch changed in a final repetition of the pattern using a three response alternative identification procedure (Higher, Same, Lower pitch). Findings suggest that both pitch interval structure and timing systematically affect the targeting of attending to the target tone. Specifically, we recovered an expectancy profile indicating that best pitch identification occurs with rhythmically on-time targets; moreover, this profile was modulated by pitch interval structure. The results are generally consistent with a model of dynamic attending in which entrainment of oscillators' instantiates low-level attending that expresses a targeting of attending in time and in pitch space.

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Temporal Expectancy at the Level of Musical Phrases: A Study of Expectancy Strength in Four-measure and Non-four-measure Phrases

This paper proposes modifications and extensions to Boltz's experiments (1989, 1993) in the investigation of the following: after hearing a musical phrase, do listeners expect the next phrase to be of the same length regardless of the specific nature of the first phrase? If not, what structural properties of the first phrase may affect the strength of the expectation? Adopting the view of four-measure phrases as the norm in Western music, two experiments are designed to compare the expectancy strength of four-measure and non-four-measure phrases. The theoretical model and methodology are based on Boltz's work, but with several major changes.

In Experiment 1, subjects hear in each trial a two-phrase melody and rate the appropriateness of the length of the second phrase in relation to the first. Nine types of phrase structure are presented: 3 measures +3 measures, 3+4, 3+5, 4+3, 4+4, 4+5, 5+3, 5+4, and 5+5. Two sets of cases are analyzed to yield results that are not predicted by Boltz's model: (1) Among cases where the two phrases are of the same length, subjects rate the length of the second phrase in 4+4 significantly more appropriate than in 3+3 and 5+5; (2) Among cases where the two phrases differ in length by one measure (3+4, 4+3, 4+5, 5+4), the length of the second phrase is rated significantly less appropriate when the first phrase is four measures long.

In Experiment 2, subjects hear three times in each trial a four-phrase melody that has one of the following phrase structures: 3+2+3+3, 4+3+4+4, and 5+4+5+5. They are then asked to tap the rhythm of the last three phrases after rehearing the first phrase. Overall, subjects show a higher tendency to elongate the second phrase in 4+3+4+4, thereby equalizing the length of all four phrases.

The results of both experiments strongly support the existence of differences in expectancy strength generated by various phrase structures. For listeners familiar with Western music, frequent occurrence of four-measure

phrases in the repertoire enables listeners to encode this type of phrase structure into schematic representations that result in a higher expectation of such a structure to recur than that of other structures.

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A Comparison of Folk Music Analysis Using the Implication-Realization Model and GTTM

This study investigates the classification of folk melodies according to cultural origin using Narmour's Implication-Realization (I-R) Model, and compares the results with those from an earlier study using the metrical and grouping preference rules of Lerdahl & Jackendoff's Generative Theory of Tonal Music (GTTM), 1983.

The earlier study showed that the metrical and grouping components of GTTM could be used to provide successful analyses of sets of folk tunes. Two sets of violin melodies were used for the study (30 Irish and 30 American), they were presented in score notation including performance information (e.g. slurs, ornamentations). The results provided a means of deriving a set of attributes that could be used as a possible means of characterization of the styles of the melodies. It was then possible to determine the relative importance of the attributes as classifiers by using decision tree induction software (Quinlan, 1998).

The same sixty melodies were then analyzed according to Narmour's I-R model. Two implicative intervals were taken from each melody and were considered according to the five Implicative Principles, enabling a set of characteristics to be determined for each. Quinlan's software was used to investigate the possibility of classifying the intervals as being from either an Irish or an American melody. Since the software is transparent it is possible to determine which characteristics best describe the Irish melodies and which the American.

Using GTTM enabled the classification of melodies as being either Irish or American with 83.3% correct classification on average, and using the I-R model 66%. An important observation from the results is that the two approaches picked out different or complementary characteristics of the melodies. The long-term aim of the authors is to define a hybrid analysis approach that can give a description (in terms of characteristics) of the stylistic features of the sets of melodies, so for this purpose complementary analysis techniques are desired. Such a hybrid approach would enable us to find both the similarities and the differences in the melodies, and could therefore aid in the general understanding of how certain types of folk music has evolved.

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Factors in Melodic Expectancy

Leonard Meyer (1956), Eugene Narmour (1990, 1992), Steve Larson (1993), and Fred Lerdahl (2001) have published theories of melodic expectation. Experimental inquiries by James Carlsen (1981), William Lake (1987), Mark Schmuckler (1989), Lola Cuddy and Carole Lunney (1995), E. Glenn Schellenberg (1997), Paul von Hippel (2000), and others have suggested paths for the improvement of existing models. The present study examines the nature of each of five factors proposed to affect melodic expectancy: stability, proximity, direction, temporal position, and hierarchic position. A method is proposed for specifying each parameter and implementing it within a prospective model that rates the expectedness of melodic events. An adaptation of Lerdahl and Jackendoff¹s time-span reduction specifies expectations about non-adjacent events. A factor informed by Mari Riess Jones notion of dynamic attending specifies the temporal target of expectations.

Session: Listening

June 18 : 4:00 – 5:20 : Room 159

Chair: Alexandra Lamont, Keele University

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What is Salient When You Listen? An Evaluation of Musicians Responses

Most research has investigated how musicians listen to music by asking them to focus on one musical variable at a time. Relatively few studies have addressed which musical attributes musicians report focusing on when they are free to choose among the many musical attributes occurring either simultaneously or sequentially as the music unfolds.

This study addresses real-time cognitive listening strategies of musicians. It investigates which musical elements musicians report focusing on as they listened to the first movement of Mozartâ€™s Piano Sonata in B flat K 333. In addition, it evaluates how the musicians reflected on their listening experience immediately after the task.

Twenty graduate music students from the Juilliard School listened twice to a recording of the first movement of Mozartâ€™s Piano Sonata in B flat K 333. The first hearing was meant to familiarize them with this movement. Before beginning the second hearing, subjects were given an unedited score of this movement, and were asked to make marks indicating their perceptions as the music unfolded. At the completion of this task, the musicians were asked to write a paragraph describing their listening experiences.

Two pairs of raters with extensive musical background coded the data independently. Overall, a measure by measure analysis of the score's markings reflected that the listeners indicated both objective categories such as structure, and melody/harmony as well as subjective categories such as dynamics, tension/resolution, and the emotional qualities of the music. The analyses of the post-test paragraphs also revealed objective and subjective category descriptions. Analyses of the paragraphs indicated negative correlations between the emotional qualities of the music and the difficulty of the score-marking task. Word count was found to be positively correlated with task difficulty. Additional correlations were found between and within the score markings and the paragraph content.

Both the score and the paragraph data seem to indicate that some musicians use a gestalt listening style while others use a more focused, analytical style. Their responses reveal that they describe what is pertinent in their listening process using both objective and subjective categories.

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Immersive Sound: Does 5.1 Surround Sound Really Make a Difference in the Experience of Music Listening?

Technological innovation has been an integral part of commercial media since the Hollywood movie industry and record companies came into existence early in the 20th century. In music listening, we find ourselves at present faced with a “new and improved” alternative … the super audio compact disc (SACD). This relatively new media format offers an immersive environment similar to that experienced in modern motion picture theaters, but intended solely to augment the music listening experience, extending the perception of sound sources within the listening space. The present investigation empirically tested the affective component of the listening experience by comparing subject verbal responses to identical musical selections in one of two presentation conditions: two-channel stereo and 5.1 surround sound.

The subject pool consisted of forty students enrolled in courses at Northwestern University. Participants were randomly assigned to one of two independent groups, listening to ten musical excerpts in one of the two presentation conditions. The experimental procedure involved presenting excerpts from ten musical selections in random order. The ten musical selections were carefully selected to include two examples from

each of five genres: alternative rock, adult contemporary, dance, jazz, and classical. Following the presentation of each musical excerpt, subjects responded using a series of thirteen verbal scales. Data were analyzed using a repeated measures analysis of variance, consisting of one between-subjects variable (presentation mode) and two within-subjects variables (VAME scale & musical genre). Preliminary results (n = 14) reveal that there is a highly significant difference in the interaction between ratings on the verbal scales and musical genre ($p < .0001$; F = 4.506). There is also a statistically significant interaction between verbal scales x musical genre x presentation mode ($p = .011$; F = 1.374). As a result, it does appear that there is a significant change between subject responses to musical excerpts when presented in surround sound vs. stereo presentation modes. Details about these differences and analysis of the full data set will be provided during the presentation.

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Study in Audience Perception of Sound Modes in Cinema

While almost all major theatrical releases today utilize soundtracks mixed for a 5.1-channel surround environment, the actual exhibition conditions of these films vary widely, both in the theatrical and home video market. And, though different modes of sound presentation may result in significant change to the experience of audience members, little empirical work has been done to determine specifically what or how significant these effects might be.

The authors here examine the effect of different speaker configurations on audience perception of eight films, drawn from four different cinematic genres: drama, action/adventure, suspense/horror, and comedy. Selected stimuli will include two examples representative of each genre. Excerpts from each film (approximately three minutes in duration) are chosen by the authors with the specific intent of highlighting moments in each film when the sound system used would be likely to make the most significant difference. These clips are then shown to independent groups of subjects in one of three presentation conditions: monophonic, 4-channel Dolby Pro Logic, and 5.1-channel surround configurations. Sixty participants, students enrolled in classes at Northwestern University, will be asked to rate each excerpt on a series of 12 verbal attribute magnitude estimation scales (VAME; Kendall & Carterette, 1993) representing the Evaluative, Potency, and Activity Dimensions identified by Osgood, Suci, & Tannenbaum (1957).

The results were analyzed using a repeated measures analysis of variance, consisting of two between-subjects variables (musical training and visual training) and three within-subjects variables (VAME scale, cinematic genre, and presentation mode). Preliminary results (n=14) reveal that there is a highly significant interaction between mean semantic differential ratings and film genres ($p < .0000$; F = 8.330), but that there is not a statistically significant difference in the semantic differential x genre x presentation mode interaction ($p = .852$; F = .829). As a result, it does not appear that there is a significant change between subject verbal responses to cinematic excerpts when presented in surround sound vs. stereo presentation mode. Possible effects of the between-subjects factors will have to be determined after the balance of subjects have provided their responses.

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"Extractive Listening:" Examining the Relationship between Vocalization and Memory During Melodic Dictation

Recent publications have commented on the need for more music cognition research whose results could be applied to aural skills pedagogy (Butler, 1996; Karpinski, 2000; Marvin, 1995). This study seeks to make this kind of connection by testing the effectiveness of a pedagogical strategy that purports to improve melodic dictation skill by developing the ability to use vocalization as a memory tool.

Many mainstream aural skills textbooks suggest that singing back a melody can serve as a

reinforcement device that will improve dictation skills. Although various studies have indicated that vocalization techniques (i.e., speaking) often enhance memory capacity, the relationship between singing and memory for music is still unconfirmed. For instance, Pembrook (1987) found that subjects tend to sing back melodies incorrectly, which then interferes with the memory process and has a negative effect on the ability to provide accurate transcriptions. In contrast, transcriptions from the few subjects that did provide correct vocalizations were extremely accurate.

Pembrook's research suggests that pedagogical strategies that focus on improving the ability to accurately sing back a melody could consequently improve dictation accuracy. This study examines the effectiveness of one such strategy, which Karpinski (2000) calls "extractive listening." In this approach, students practice a sequence of skills that progress from accurately singing back short melodies to singing back the first segment of a longer melody while the rest of the melody is still sounding. Retention is, therefore, demonstrated first through accurate vocalization and then by correct notation.

Thirteen sophomore aural skills students participated in this study. During the first task, three melodies of increasing difficulty were presented four times each and students notated as much of the melody as they could after each hearing. A second task followed the same procedure, except that students sang back the melodies after each hearing prior to notating it. Results from this pretest indicate a generally poor ability to provide accurate transcriptions and accurate vocalizations. After using the practice strategies outlined above, students will be given a posttest that follows these same procedures. Since this posttest will occur at the end of the current semester, analysis of data and observations regarding the effectiveness of this strategy are forthcoming.

Session: Development 1

June 19 : 9:30 – 10:30 : Recital Hall

Chair: Peter Pfordresher, Univ. of Texas, San Antonio

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The Influence of Style and Tempo in Pre-natal Music Exposure

This paper addresses theoretical and technical issues in the study of very young infants' responses to music, and considers the potential effects of different styles and tempi of music used in pre-natal exposure on post-natal recognition.

In the field of infancy research, the debate over preference for novel or familiar stimuli is longstanding. This is central to the majority of research endeavors, given that discrimination can typically only be measured in terms of the attention the infant gives to a given stimulus. In music psychology, research has indicated that infants prefer *familiar* musical stimuli (e.g. Saffran *et al*., 2001), and in addition that certain *types* of musical stimuli (fast and loud music) are more intrinsically interesting to infants, irrespective of familiarity or of style (Lamont, 2001). Parental musical preferences may, however, also play a role in participants' willingness to adhere to extensive experimental requirements such as regular playing of specific pieces of music.

The paper will outline a proposed program of study that attempts to address these issues in an ecologically valid yet empirically rigorous manner. The study attempts to explore pre-natal exposure and measure post-natal recognition of different musical stimuli over a relatively short time-span. Mothers are to be asked to provide 6 minutes of daily exposure to a given piece of music for the last 6 weeks prior to their due date (33 weeks onwards). Issues of compliance and long-term memory effects will be considered in this familiarization period. Newborns are then to be tested on their responses to different pieces of music, including the one they were familiarized with, at varying time intervals. Theoretical considerations of time delay and methodological problems in testing will be discussed here. Finally, the potential problems in interpreting style and 'arousal' differences alongside familiarity will be explored.

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Infants' Perception of Transposed Melodies

In music, pitches are defined by height and chroma. It has been suggested that infants are similar to adults in their perception of tone chroma (Demany & Armand, 1984), in that they perceive two notes an octave apart as having the same chroma. In previous reports, using simple tonal melodies, we have shown that infants learn to treat a transposition as equivalent to a base melody faster for transpositions of the 4th and 5th than for the octave (Kim & Werner, 2001). This is opposite of what would be predicted if infants recognized the common chroma of the base melody and its octave transposition. In the present study, infants' and adults' perceptions of the 3rd, 7th and 9th transpositions were tested using an observer-based procedure. The 7th and 9th intervals bracket the octave in tone height, but do not share chroma with the base melody. After having heard a standard background melody, subjects were trained to respond to a training melody of a different contour and key. Once that discrimination had been learned, transpositions of the background melody were introduced. Each test condition contained the original background melody and one type of transposition of the background melody. Both adult and infant subjects were then trained to continue to respond to the training melody, but not to the transposition of the background melody. If infants are similar to adults in that they recognize the shared chroma of the background melody and its octave transposition, they should learn to ignore the octave transposition more quickly than other transpositions. Results indicate that except for the transposition to the 9th, infants needed more trials to learn that farther frequency transpositions were simply transpositions of the background melody, including the octave. The numbers of respondents to presentation of the first transposition and response latencies were also analyzed. For infants there was no indication of special processing of the octave except a marginal result in the latency data. These results suggest that infants perceive tone

chroma based on frequency distance rather than octave-equivalence. Potential explanations for these responses, including immaturity of auditory processes, are being explored.

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Mothers' Speech and Singing to Deaf Infants with Cochlear Implants: A First Report

Caregivers typically speak and sing to their infants using a distinct style known as infant-directed (ID) speech and singing. Because infants prefer ID to adult-directed (AD) speech and singing, their positive response may encourage parents' use of this vocal style. However, hearing-impaired infants who cannot hear differences between ID and AD vocal styles may not motivate parents' use of ID speech and singing. With the recent expansion of cochlear implant (CI) criteria to include infants, it is critical to assess the changes in mothers' speech and singing to infants as they acquire auditory skills via CIs, compared to mothers' speech and singing to normal-hearing (NH) infants. To establish NH mothers' vocal style when speaking and singing to their CI and NH infants, we digitally recorded NH mothers speaking and singing to their 4- to 10-month-old NH infants (N=6) or to their 17- to 37-month-old CI infants (N=6). For the CI infants, the average age at implantation was 16 months, and the average duration of CI use (i.e., "hearing age") was 11 months. We also recorded mothers' AD speech and infant-absent singing. We analyzed the recordings in terms of the acoustic features known to characterize ID speech and singing. The results of the speech analyses revealed that the average, minimum, and maximum pitch levels were higher in ID speech than AD speech, and utterances were shorter in duration in ID speech than AD speech, regardless of infant hearing status. Average pause duration was longer in ID speech compared to AD speech when directed to NH infants, but not when directed to CI infants. The results of the song analyses revealed no significant differences in pitch or phrase duration between infant-present and infant-absent conditions, regardless of infant hearing status. Phrase-final duration was longer for infant-present than infant-absent singing only when directed to CI infants. These preliminary findings suggest that mothers speak and sing to NH and CI infants in similar styles despite the chronological age difference in the two infant populations. That is, mothers' speech and singing to infants is influenced by "hearing age" rather than chronological age.

Session: Development 2

June 19 : 11:00 – 12:20 : Recital Hall

Chair: Peter Keller, Max Planck Institute

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Musical Preferences in Pre-schoolers: The Effects of Pace and Familiarity

This paper investigates the musical preferences of children aged 3.5 years, using a new interactive procedure which allows data to be gathered at a valuable stage in development that has traditionally been difficult to study experimentally.

Research into the development of musical preferences has either employed simple measures of discrimination, as used extensively with infants (e.g. Schellenberg & Trehub, 1999), or verbal labeling of musical styles, as in questionnaire studies with older children and adolescents (e.g. Tarrant *et al*., 2001). The current study builds on the infant discrimination paradigm by allowing participants to manipulate the presentation of music themselves, selecting from a larger number of different musical extracts in a single testing situation. The effects of the intrinsic factor of musical pace and the extrinsic factor of familiarity are both explored here.

A children's toy keyboard was customized to interface with a portable computer and speakers, enabling a real extract of music to be associated with each of the four keys and the timing and order of key presses to be recorded. Three extracts of music were presented to all participants: two unfamiliar pieces contrasting in pace (fast and loud versus quiet and slow), one generally familiar piece (a fast and loud pop song) and one individually familiar piece (used in an earlier prenatal study, and varying between participants). After being shown the keyboard and played each piece of music, participants were then invited to play with the keyboard themselves. Interactions were also video-recorded to enable analysis of verbal interactions and non-verbal gestures.

Results from 20 participants aged 3.5 years will be presented at the conference. Pilot data indicates that pace interacts with familiarity in children's preferences. Children show strong preferences for fast and loud music regardless of familiarity, although familiarity can increase these preferences. Slow and quiet music is not typically preferred. The results will contribute to our understanding of the development of musical preferences, and in particular will illuminate the effects of familiarity and past exposure on musical preferences at an age when children are not typically considered to be making active informed choices about their music listening habits.

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Children's Understanding of Music: Procedural and Declarative Knowledge

This paper aims at showing the extent to which children's understanding of music can be articulated through language and conveyed through playing. It addresses the issue of *how* an instrumentalist's understanding of music, as a form of musical thinking, can be expressed at early stages. The method involved case studies with cellists aged 9, 12 and 14, over 20 weeks. Interviews, practising and performances were recorded and analysed. The participants learned three different pieces of music. In Study 1, they received no guidance concerning their approach to the piece. In Study 2, they were involved in a simple analysis of the piece before practising it and drawings of the phrasing were explored in order to investigate aspects of their understanding of the piece prior to playing. In Study 3, their playing was preceded by a series of practical activities - colouring the score, watching performances, singing. Sight-reading and performances were evaluated by external examiners and by the children, five years into the research. The results of Study 1 show that their interpretation was limited by technical and conceptual difficulties - practising by repeating the whole piece led to developing a "faulty" representation of the music, incorporating rhythm and pitch mistakes. Study 2 provided a firmer basis from which to detect errors and to focus on aspects other than pitch and rhythm. Interviews showed that at times, the children could describe their understanding of the piece

verbally, but could not match that with their playing and at other times, they could play more expressively, but could not talk about their understanding. Study 3 revealed that their playing matched their singing, reaching higher levels of expressiveness. Thus, this investigation shows that a child's understanding of music cannot be traced simply by observing their playing and suggests that there is a clear gap between what children *know* about music and what they can *express* in their playing, or even talk about. Thus, children's conceptualisation of music is a complex mixture of explicit knowledge articulated through language, and implicit understanding conveyed through their playing. Singing, seen as a concrete form of musical thinking, was the means of connecting the children's thought with their action in cello playing and this has important pedagogical implications.

Attendance was made possible by a grant from The British Academy.

Posters

June 19 : 9:30 – 12:20 : Recital Hall Lobby

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Acoustic Cues to Emotion in Music Across Cultures

Music is often experienced as having an emotional quality, but this experience is difficult to interpret because we almost always listen to familiar music from our own culture. Are associations between music and emotion the result of enculturation, or are some musical cues to emotion universal? In a recent study by Balkwill and colleagues, Western and Japanese listeners judged the emotional meaning of 120 field recordings of Western improvisations, traditional Japanese music, and North Indian music (mean duration = 30 s). All music samples were chosen and performed with the intention to evoke a particular emotion: joy, sadness, anger, and peacefulness. Listeners also judged the loudness, tempo, and complexity of each excerpt. Emotion judgments were significantly related to judgments of auditory parameters. In the present study, we extended and corroborated these findings by revealing relationships between intended emotional meaning in music and objective measures of acoustic parameters that may act as cues to emotional meaning. Objective measures of several acoustic parameters were obtained, including measures related to event density, amplitude, and frequency. The findings indicated that acoustic parameters varied significantly depending on the intended emotional meaning. A comparison of these links for Western, North Indian, and Japanese music revealed both similarities and differences across cultures in the relation between acoustic parameters and emotional meaning. Results are compared with listeners' judgments and discussed in the context of the Cue-Redundancy Model.

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The Expressive Role of Beat Subdivision in Jazz

This study examines the nature of jazz beat subdivision in order to assess its expressive function as well as its accordance with the "swing triplet" theory. The Beat-Upbeat Ratio (BUR) describes the temporal proportion between two subsequent eighth-notes by measuring and comparing their duration. Thus, two equally long (or "straight") eighths yield a BUR of 1.0, whereas a BUR of 2.0 represents a triplet (long-short) configuration. I used a digital sound editor to examine three specific BUR phenomena. (1) BUR fluctuation is sometimes linked to properties of phrase structure. Musical analyses reveal phrase demarcation points where shifts in melodic character (e.g., from scalar to arpeggiated) coincide with corresponding changes in BUR value (e.g., from lower to higher). (2) In addition to involving a restatement of pitch and rhythmic information, motivic repetition often preserves BUR values. Such correlation also occurs within jazz "heads" (song melodies), as illustrated by John Coltrane's rendition of eight identical fragments in the melody of "Good Bait." (3) BUR histograms are displayed for post-bebop giants Miles Davis, Bill Evans, and Dexter Gordon. Their contrasting BUR profiles suggest that different performers employ different approaches to beat subdivision. For example, 69% of Dexter Gordon's collected BURs lie in the 0.9 – 1.1 range, as compared to 33% and 20% in the cases of Miles Davis and Bill Evans, respectively. Also, their combined BUR average of 1.24 is not only far removed from the supposed "swing triplet" of 2.0, but also significantly lower than those values reported in recent studies.

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Temporal Duration Judgment with a Variable Induction Sequence

The Interval-based Memory model, rigid Beat-based model, and Oscillator-based timing model all propose mechanisms to explain contextual sequence effects on temporal duration judgment. The three mechanisms provide different explanations for the improvement in performance when the judgment intervals are preceded by an isochronous induction sequence. The current experiments evaluated predictions of these models by assessing duration threshold as a function of variability in the preceding contextual induction sequence. In all conditions, two judgment intervals were presented, with the task of the participants to indicate whether or not the judgment intervals were equal in duration. Context on each trial was provided by an initial five-interval induction sequence whose average interval duration always equaled the first judgment interval. The conditions differed in the magnitude of variability in the induction sequence. The typical Interval-based Memory model uses the average of the induction sequence intervals as the judgment standard for the final temporal duration comparison; if only the average is important, this mechanism should be unaffected by interval variability. For the rigid Beat-based mechanism, relative duration judgment is based upon synchrony/asynchrony between the internal beat and regularity derived from the induction sequence for temporal duration comparison; significant variability in the induction sequence should disrupt judgments based upon synchrony/asynchrony. The Oscillator-based mechanism selects an internal oscillation that entrains to the rate of the induction sequence for temporal duration comparison, but the rate of the internal oscillation can adapt rapidly to small changes in phase; the relevance of the internal oscillation to the judgment task should be poor when variability is high, especially when the variability is present in the final induction sequence intervals. Across several experiments, judgment thresholds were a skewed, inverted-U shaped function of magnitude of variability. Thresholds also were less impacted when the induction sequence interval average was constant within trials than when allowed to vary within trials. Also investigated were the effects of confining interval variability to the initial or final intervals of the induction sequence within a session. Overall, results were mostly, but not entirely, consistent with Oscillator-based timing.

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Pitch Awareness and Phonological Awareness

In the past few years, many researchers have presented assorted studies showing the benefits of music at the cognitive, kinesthetic and socio-emotional levels. Despite this growing interest, few specialists have attempted to establish a link between performance in the processing of pitch awareness and academic success, notably in the development of reading strategies. In contribution to this field of study, our study proposes to observe if there exists a correlation between the performance of pitch awareness and phonological awareness skills. This study involved a sample of 13 students (n=7 girls, n= 6 boys), registered into the preschool program of the Québec school, made up the sample study (average age= 5½). The Tonal Test (Primary Measures of Music Audiation, Gordon, 1979) was used to measure the performance in pitch awareness processing. Phonological awareness skills were measured with the help of L'Épreuve de métaphonologie by Armand and Montésinos-Gelet (2001). In this study, the Rhythm Test (Primary Measures of Music Audiation, Gordon, 1979) was also used as a control test. The results show a significant link between pitch awareness and phonological awareness performance. They also show that there is no relation between rhythm perception and the processing of pitch awareness nor between rhythm perception and phonological awareness skills. Should this prove to be true, it will then be obvious, taking into account the wealth of research having established a link between phonological skills and reading skills (Lecocq, 1991), to reconsider the place of a musical education and its positive role on one of the major factors in learning to read.

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Effects of Music Distraction on Neurophysiological Markers for Pain

A number of studies investigating music analgesia suggest distraction as the mechanism of effect; others point to music's ability to modulate affect. The frequently inadequate music controls, response measures, or pain models employed in most studies investigating musical applications for analgesia make it difficult or impossible to draw definitive conclusions regarding mechanisms. Our model of music analgesia defines pain as a multivariate network of physiological and neurophysiological responses described more generally as the Defense Response (DR) identified by Sokolov. This model provides a framework for separately assessing the contributions of attention and affect to the modulation of pain.

We apply a music listening task for engaging attention and observe responses to painful shocks. If attentional mechanisms contribute to the DR, then attending to the music task and not the shocks will produce significant changes in response to painful stimulation.

Subjects participated in 2 melodic error detection conditions and a no task control. Subjects heard a repeating melody and detected deviant (octave displaced) tones, while ignoring missing and background tones. Background tones varied randomly over an octave range with the range placed 15 semitones (easy) or 1 semitone (hard) above and below the melody. In the control, subjects heard only background tones. Subjects received painful shocks to the tip of one finger in each condition. Skin conductance (SCR), evoked potentials (EP) and other physiological measures were collected.

In a pilot study of 6 subjects, P250 and SCR were significant for condition ($p=0.023$ and $p=0.015$, respectively). Paired comparisons showed significant mean differences between control and both easy and hard tasks for P250 (9.3 and 7.8, respectively, $p<0.05$) and for SCR (3.26 and 3.42, respectively, $p<0.015$). Effect sizes $[(X_{hard}- X_{control})/ SD_{control}]$ for other physiological measures suggest a larger sample will reveal additional meaningful effects.

Engaging attention in a challenging music task effectively reduces neurophysiological and physiological indicators of pain. This result provides a benchmark for future studies on the effects of music listening strategies and music induced affect on pain.

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Perceived Metrical Accent in Musical Rhythms

This study addresses the factors of tapping period, tapping phase, and multiple performance variability as it elaborates on previous studies of musical beat-tracking by Parncutt (1994), and McAuley and Semple (1999). In Parncutt's study, six stimulus rhythms were presented at varying tempos and listeners were asked to tap along with the perceived pulse. McAuley and Semple's study re-examined Parncutt's rhythms plus a new one and addressed the effect of tempo and musical experience on perceived beat period. The goal of this study was to repeat earlier conditions while addressing some unanswered issues and to study a larger set of experimental rhythms.

Five rhythms of the earlier studies (excluding the simple pulse train) and seven new rhythms were tapped along with by subjects. Tempo was not varied and was set at 150 events per minute for all rhythms. A trial consisted of all 12 rhythms presented multiple times in random order – each rhythm beginning once from each of its possible initiation conditions. Subjects tapped through two trials. Subjects came from a wide variety of musical backgrounds, ranging from non-musicians to world-class professional musicians.

Subjects tended to agree with each other when tapping to some rhythms, regardless of which beat was presented first. Starting positions of more complex rhythms seemed to have a much stronger influence on tapping. Consistent with earlier findings, subjects tended to choose pulses preceding longer periods of silence as landmarks for tapping. This is especially well shown with a complex rhythm where it is very difficult to align a steady tapping to correspond with both the first and last event of a three-event grouping. Musicians were

more likely than non-musicians to tap through more difficult rhythms such that 2 cycles of a rhythm became 1 cycle in their tapping. Of particular value in this experiment is that subjects heard the same rhythms a number of times and their consistency in tapping across trials offers a new appreciation for understanding the consistency with which rhythms are beat-tracked across subjects.

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Tonal Violations Interact with Lexical Processing: Evidence from Cross-Modal Priming

Cross-modal priming studies provide a framework for investigating the integration of information perceived by different modalities. Though priming is thought to occur presemantically in the perceptual pathways, it is evident that some stimulus attributes must be either shared between perceptual systems or integrated by a domain general mechanism for cross-modal priming to occur. Two experiments were conducted to investigate the integration of simultaneously presented auditory and visual information. Musical stimuli were used to establish two different contexts: one in which tonal expectations were violated by a target chord, and another in which expectations were met. Participants were asked to perform a visual lexical discrimination (word/ nonword) task while listening to the musical stimuli. To ensure that the participants were attending to the auditory stimuli, they were prompted after performing the lexical task to decide whether the last chord in the sequence was related or unrelated to the preceding chord. There was a significant reaction time interaction between the auditory and visual stimuli on the lexical discrimination task. Participants were faster to identify words when they were presented with the expected target chord than when the chord was unexpected, but faster to identify nonwords when the target chord was unexpected rather than expected. Both the visual and auditory stimuli have familiar and relatively unfamiliar exemplars, and this interaction suggests that if stimulus familiarity is congruous between the visual and auditory domains, cross-modal priming will occur. The error rates to the chord discrimination task also show a significant interaction between the auditory and visual stimuli, revealing that congruity between the two stimulus types resulted in greater response accuracy, even among musically trained participants who could differentiate between the chord sequences significantly above chance. These cross-modal interactions reveal that the brain will search for congruity between simultaneously occurring stimuli. Though there is no explicit relationship between the musical and lexical stimuli used in these experiments, congruity can be assessed if one considers the perceptual familiarity of the stimuli. These results suggest that congruous levels of familiarity are facilitative respective to incongruous levels of familiarity, and that encountering a relatively unexpected stimulus in one modality will prime the perceptual systems to anticipate other unfamiliar stimuli.

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Are ERPs Responses to Harmonical Changes Related to Spontaneous Rhythm and Musical Intelligence?

The aim of the present work was to investigate possible correspondences between ERPs responses to harmonic changes in musical recordings and various factors of musical intelligence. Among these factors, particular attention was paid to subjects' spontaneous rhythm because a pilot study with ERPs had previously revealed differences in attention displayed by subjects with different spontaneous rhythm while processing rhythmic stimuli. In the current investigation, twenty non-musicians, whose spontaneous rhythms were preliminary assessed, were invited to listen to piano excerpts selected for their changes in harmony. ERPs were recorded when a harmony change occurred. Afterwards, subjects were administered the Wing Standardized Tests of Musical Intelligence

according to the revised Italian adaptation (Olivetti-Belardinelli, 1995). The resulting spontaneous rhythms and scores of musical intelligence tied to rhythm and harmony processing correlated with ERP responses to harmony changes. Implications of these results will be discussed within the framework of a cognitive systemic model of organism-environment interactions.

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Music Perception Processes from a Social Representations Approach

The Social Representations approach developed by Moscovici is a sociological form that addresses issues concerning different perceptions that socially configured subjects build from the same object. According to this approach, perception is the result of processes that negotiate between shared and divergent meanings concerning different social objects. These negotiations take place within and between social groups. Every musical object (i.e., a constructed sound organized and considered by a cultural group) is perceived, represented, and reconstructed within an individual's or group's cognitive system, then integrated within its system of values as a function of its history, as well as its ideological and social context. Members of a social or reflexive group thus create musical objects, assign meaning to them, elaborate and share rules, plus provide justification for their perceptions within their daily practices. This view is more expansive than conceptions of perception as simply being prompted by an acoustic stimulus. Rather, perceptions are not solely affected by factors inherent to the individual (such as motivation, conflict, personality), and do not result exclusively from interactions between the individual and the object (i.e., the "stamp" imprinted by its formal structure, timbre, melody, harmony, etc.).

What are the reference systems for perceiving objects, and how do they work? A sound is selected and re-contextualized. Selected elements "coincide" with the perceiver's intent to assign meaning to the sound. Re-contextualization causes selected elements to have value for the group. Since the output of re-contextualization differs for each group, the same object can be represented in different ways. Central cognitions (i.e., organizations of selected elements in a complex of sound images) then are formed, establishing a 'new musical object'. Classification of this structured percept, including the assignment of a name to the object, then is derived from the representation constructed by the subject with respect to social relations. By categorizing a musical object, we can integrate it in our socio-cognitive scheme, make it "familiar". The meaning of the object derived from categorization will guide conduct toward the object. In this way, the Social Representation approach makes it possible to explain and improve educational practices involving music perception.

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Harmonic Functional Categorization

Meyer (1956) held that expectancy is fundamental to meaning in music. This raises the question of what it is that listeners expect. It seems reasonable to believe that our expectations are based off of perceptible aspects of music. Rameau's (1722/1971) system of labeling chords by their roots is often taken as a theory of chord perception and categorization. I report an experiment that shows discrepancies between this system and listeners' perceptions, as well as an alternative model, the Harmonic Functional Categorization model, which posits that chords will be perceived as the same when they predict the same possible future progressions. This experiment compares IV chords and ii6 chords both in and out of context, controlling for other factors, which could affect discrimination between chords. Listeners made a same-different judgment in an A-B-X design.

Results showed listeners could distinguish between the IV and ii6 chords of any key when played on their own, in the absence of harmonic context. However, listeners could not distinguish between (1) and (2) unless the outer voicings were different. This pattern of results held in the minor mode as well, between the iv and ii°6 chord. Chord pairs that have the same interval patterns as the IV and ii6 chords but different harmonic functions, such as the middle chords in (3) and (4), were found to be significantly easier

to distinguish. Significant independent effects of voicing and chromaticism were also found.

Since chords like IV and ii6 can be distinguished out of, but not in context, the harmonic context must be constraining our ability to perceive differences between chords, specifically between chords of the same function. This supports the idea that we perceive the functions of chords as a whole, rather than deriving it from the notes or intervals. This work also adds a conceptual backdrop to understanding Meyer's theory of expectation in music.

(1) I – IV – V7
(2) I – ii6 – V7
(3) I – V – I
(4) I – iii6 – I

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An Investigation on the Relationship between Visual and Auditory Signal

The integration of sound and vision has been a topic of discussion for philosophers, musicians, visual artists, and scientists since the time of ancient Greece. Some have claimed that utilizing eye and ear simultaneously enhances the overall affect. However, until now, this literature has never been used as a basis for the process of real-time transformation from sound and music into visual images.

The present empirical investigation was motivated primarily by Walker's (1987) investigations. In the context of the present investigation, musical sound and visual images are examined in relation to two primary components: direction and magnitude. The directional component includes aspects such as ascending-descending (e.g., pitch height), increasing-decreasing (e.g., intensity of sound energy or hue value within the color spectrum), etc. All auditory and visual parameters were examined using three magnitudes of value change: small, moderate, and large. As a result, three versions of each audio-visual composite were created: 3 pitch color composites, 3 pitch-size composites, 3 pitch-shape composites, 3 pitch-location composites, 3 timbre-color composites, etc.; resulting in a total of 48 audiovisual composites.

Between-subjects factors of interest include level of musical training and level of visual training. In the experimental procedure, subjects were asked to evaluate the "degree of match" between the audio and visual components of a series of A-V composites presented in random order. Subject responses will reveal the degree to which various aspects of the musical sound and visual image influence the perceived "match." Future work will utilize these findings to create a real-time algorithm for the transformation of sound into image.

References

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The Dynamic Interpretation of the Cognitive Music Processes

This research tends to show that the recent links that have been made between the cognitive sciences and musical composition do not depend on a simple contingency. They are clearly indicated in more than one respect as signs of ancient and fundamental questioning, related to the constitution of our knowledge of music. These links call into question the 'classical' approaches to the creative processes, as well as the different forms of the problems relating to their representations. The point of departure for this research is based on the paradigmatic change taking place within the cognitive sciences around the current consensus established by connectionism, the importance of which can be measured through the orientation of a praxis, now common in the exploitation of neuronal architectures, which offer new perspectives to musicologists and composers, in both theoretical and experimental terms. Since analysis of the biological model highlights the fact that the processes of perception, decision making, and more generally of cognition, result from emergent phenomena, natural manifestations of the progressive process within the network of interaction with their environments, it would seem that the rational point of departure of a theoretical interpretation requires an obligatory detour via a general study of the dynamic

systems themselves. The fundamental consequence of this organizational mode is to highlight a cognitive process in terms of an attractant. One should therefore attempt to give an adequate interpretative framework to the compositional process and to the musical phenomenon itself according to this new concept. After demonstrating the fundamental role occupied by the attractants in the field of cognition, we will propose a theoretical discussion concerning their identification in the field of musicology and their experimental reconstitution within the framework of the production of an automaton. This new approach reveals the possibility of modeling of the perceptual process, which could generate applications in terms of systems of compositional aid.

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Time-Space of Music

There are two unifying powers in the cosmos of music: the force field of tonality and structured time. Combination of these powers constitutes the tonal chronotope.

When explaining music with the help of images of visual arts and mental images of science, we extrapolate on temporal art of music such spatial categories as "module", "negative space", "circular" and "square", "horizontal" and "vertical", as well as notions of "color", "hidden dimension" and "force field". We can also present music in terms of geometry; such presentation is helpful in explaining the difficulties of mathematical formalization in music.

Fabric of music is woven with tones placed in time. Tonality is a system of relations between musical sounds that works like force of gravity in music. The tonal gravity shapes musical compositions and holds them together; without tonal forces, there would be no musical structures. In tonal force field, some tones are centers of stability and attraction to other tones that gravitate toward these tonal centers with various degree of intensity. These tonal centers are the points of reference to our perception.

The highly abstract process of auditory pattern-recognition in music, "unconscious calculation" in Leibniz' words, results in a re-creation of emotional (non-discursive) states. The evolution of acoustical signal in music happens in a highly arbitrary situation of minute relations and within chain of events with a strong connection to a previous history. Therefore, we cannot divide fabric of music on independent and equable quantities. The tonal chronotop can be compared to a living being where structured time is like a skeleton and tones are like flesh: the structured time and tonal field are intertwined and interdependent.

The tonal chronotop is not an invention but a result of a gradual, millennia-long process of discovery; our intuitive awareness of the tonal field arrives to us as a cultural gift. Nature talks to us through music, through invisible immaterial structures we perceive intuitively. We resonate physically with sounds in music, and we resonate mentally with ideas expressed through organized sounds.

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Intervals and Intonation in South Indian Classical Music

Contrary to popular belief that South Indian classical (Carnatic) music today uses 22 or more distinct intervals per octave, recent pitch tracking results have suggested that Carnatic music employs a core set of only 12 distinct constant-pitch intervals, similar in nature to the Western semitones. (However it was also observed that these 12 intervals were modified at various times by pitch inflexions, which may lead to the perception of microtonal intervals.) Though crucial for computer analysis and synthesis of Carnatic music, the interval values of the 12 basic constant-pitch notes and the variability in intonation that is acceptable in practice are yet to be determined. Since it is difficult to extract such information directly from pitch measurements of actual performances, specialized and well-controlled experiments using top-notch musicians are needed. In the development of such experiments and the analysis of the results thereof, it may be useful to consider some well-known tuning systems and determine if they could possibly apply to Carnatic music. In addition to discussing such theoretical tuning possibilities for each note, we consider various factors that may play a role in intonation such as the use of the tambura drone in almost all

musical settings, the use of modern electronic replacements for the tambura, the properties and construction of some indigenous musical instruments like the veena and the flute and the influence of Western music. Finally, since there aren't any precise tuning standards in use today, it may be interesting to discover how intonation varies with different (accomplished) musicians who have been trained by different gurus.

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Reaching (and Not Preaching To) Adolescents: A Music-Based HIV Prevention Intervention for Urban Adolescents

This paper illustrates the process of conducting and evaluating a theoretically driven, music-based HIV prevention intervention among urban adolescents. Based on the information, motivation, behavioral skills (IMB) model (Fisher & Fisher, 1992; 2000), and the natural opinion leader (NOL) model of health behavior change (Kelly et al., 1991), we examine the hypothesis that musically talented opinion leaders from within a high school can effectively write, record, and distribute HIV prevention themed music to their peers to increase motivation to engage in HIV preventive behaviors, as well as intentions to engage in HIV preventive behaviors, and HIV prevention information levels. To measure the effects of the intervention, approximately 400 students enrolled in health classes at each of three large multiracial urban high schools (1 treatment school; 2 control schools) completed measures of HIV prevention information, motivation, behavioral skills, and behaviors, both pre and post intervention. Results indicate that among students who had never been sexually active at pre-test, perception of pro-abstinence social normative support was stronger for students in the treatment school. Increases in perceived vulnerability were also observed among these students. The incorporation of music as a communicator of pro-prevention social norms and social influence into interventions that target adolescents is discussed.

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Current Problems with the Perception and Interpretation of Music

Current musical trends reflect styles spanning several centuries. Frequently, we may listen in one concert to music reflecting different genres, historical styles, and composition techniques. Such a complicated combination of various styles/languages demands that both audience and musician possess the proper lexicons. Listening therefore should develop as a function of one's ability to search appropriate criteria of appraisal, and perceptual problems should derive from the reliance on multiple languages as a basis of communication.

Musical communication occurs along many lines, including general communication (composer–composition– performer–audience), as well as binary coordination (composer–performer, composition–performer, performer–audience). Given a reliance on multiple languages, the interpreter comes to serve the most important role in musical communication. The performer is foremost in realizing this function.

Performers complete various communication activities, including rendering many genres for solo, ensemble, and orchestral performance in small or large halls, and potentially for recording. All of these activities require several perceptual and emotive actions in the brain, with musical hearing forming the dominant basis of any performance. The musical hearing of performers is argued to differ from their audience by creative and impulsive features. The famous German pianist and teacher K. A. Martinssen suggests that the most important aspect of a performer is the capacity of the inner ear to react to the nuances of emotion, and to transform that to a beautiful sound. Moreover, the musical hearing of performers depends on the process of playing, including temporal organization of the piece, as well as the control of mental, emotional, and physical aspects of performance. Finally, musical hearing has a very close connection with the tonal organization of the composition (language, structure, and style).

Stylistic forms of tonal organization and composition techniques are tuned to the proper types of musical ear. For example, the alleatoric technique emphasizes the importance of timbre, along with serial pitch processing. Therefore, the correspondence between a text and its

interpretation is determined by stirring up the proper perceptual abilities. On one hand, it makes understandable the musical language(s) of a composition, and on the other, makes for expressive performance.

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Walking the Meter on Computer-Controlled Piano Music

Empirical rhythm research usually works with high discriminated perceptive and motoric preferences, like tapping a finger or a foot to a metronome click while sitting in a chair (e.g. in investigations on a "biological clock"). This leads to certain results, but can't explain, how and why our movement is connected to the context of sounding music. On the other hand, music-educational methods like "eurythmics", dealing with large space body movement like walking the meter on complex sounding structures, have lead pupils to obtain better knowledge on music rhythm and timing for over 100 years (Methode Jaques-Dalcroze). This success has even been demonstrated in pupils who don't play a musical instrument!

There has been little research on "performed perceptions." Recent technology, however, is now making it possible to investigate the relationship between music and human movement. The purpose of this research is to develop a wireless technology that permits "holistic" rhythm investigations. The technology focuses on measuring senso-motoric processes like human locomotion as an "interface" for research in musical timing perception. The technology was tested in the laboratory by having subjects of different ages and musical skills in single sessions to walk the meter around a computer-controlled Yamaha grand-piano. Stimuli were given by automatic performance of the "real" instrument and of its electroacoustical replication (speakers hidden in the piano). The temporal structure of the gait was measured through piezomechanical shoes and documented on hard disc-recording (Ch1), simultaneous to the rerecording of the acoustical stimulation at the subjects ears (Ch2). The influence of "original" and "electronic" acoustical sounding stimulation on the temporal synchrony of walking was compared. Significant intra-individual constancies in the synchronization-strategy and high-significant inter-individual negative asynchronies (50 to 200msec) were observed. Many subjects reproduced individual synchronization "signatures." Active trained musicians performed more equal synchronies than musical laymen. Neither sound-reproducing systems (original or electronic) lead to significant differences in the synchronization of walking. This new recording technology is a precise (+/- 2 msec) tool that has applications in other areas, such as dance education, music therapy, and ethnomusical research.

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Musical Form and Habituation Theory

Compared with other stimuli, most music exhibits a high degree of repetition. A reasonable theory might suggest that musicians attempt to repeat passages as frequently as possible but introduce novel or contrasting passages to forestall boredom or annoyance due to excessive repetition. Classic habituation theory provides a useful framework to test this intuition. Specifically, habituation theory suggests a number of strategies where periodic dishabituating stimuli might be introduced as a way of preventing the desensitizing of listeners.

A study of repetition patterns was carried out by analyzing a cross-cultural sample of 50 musical works. The sample included folk, popular and classical repertories from around the world. By way of illustration, the sample included Bolivian Chapaco music, 15th-century Chinese guqin music, Hawaiian slack guitar, Inuit throat singing, Swedish Storpolskan, popular Ugandan music, etc. In sampling the works for study, we explicitly chose works that exhibit repetitive structures employing identifiable units of repetition. Repetition patterns were then identified aurally by trained auditors who followed a strict analysis protocol. Separate repetition analyses were carried out for melody, dynamics, and instrumentation. The patterns of repetition were then encoded in a computer database.

Control patterns were created by randomly reordering musical sections within a work. In the first instance, we show that the repetition patterns differ significantly from simple

random re-orderings. A series of hypotheses arising from habituation theory were also tested. For example, we tested the hypothesis that the number of successive repetitions of a passage tends to become fewer as the work progresses -- consistent with the shortening of habituation-dishabituation cycles. Current results are disappointing. While the patterns of repetition are far from random, it is not clear that they are structured to avoid boredom, habituation or annoyance.

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Verbal Symbols of Musical Sounds: An Empirical Investigation of the Relationship between Drum Sounds and Speech Syllables in North Indian Tabla Drumming

A number of musical traditions map elements of a musical system onto a set of vocables (nonsense syllables). For example, Western music uses the syllables do, re, mi, etc. to map the pitches of a diatonic scale in solfège. North Indian tabla drumming has a particularly rich system of vocables. Teaching and performance on this instrument involves a large syllabary, in which particular drum strokes involving either one or both hands are named by particular syllables (for example, ta, dha, tin, tun, kat, ghe etc.). This system allows players to remember and communicate complex percussive sequences using purely verbal syllable strings.

In this study we investigate the hypothesis that the pairing between vocables and drum sounds in tabla drumming is not arbitrary (unlike the Western solfege system). That is, we test the idea that the mapping between speech sounds and drum syllables has an acoustic and perceptual basis, i.e. is an instance of "sound symbolism" (onomatopoeia). We investigate this hypothesis via acoustic comparison of drum and speech sounds and by perceptual experiments.

Eight vocables and their corresponding drum sounds were collected from 6 professional Tabla players in India. Analysis revealed that acoustic properties of drum sounds were reflected in a variety of phonetic components of vocables: spectral centroid, rate of amplitude envelope decay, duration between the release of consonants in a cluster, fundamental frequency, and the influence of aspiration on the balance of low vs. high frequency energy in a vowel. We also describe a perceptual experiment, which demonstrates that naïve listeners can match vocables to drum sounds. The use of aspiration in musical sound symbolism is a novel finding which illustrates how the phonetics of a particular language (Hindi) can influence the form that sound symbolism takes. Supported by Neurosciences Research Foundation.

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Neural Correlates of Music Perception: A MEG Study

We use magnetoencephalography (MEG) to study the neural correlates of *authentic* music perception, with no manipulation of the musical score that isolates artificial category boundaries for processing specific attributes of music. The MEG experiment was designed around the structure of Frantz Liszt's *Etude d' ecercution transcendent d'apres Paganini no. 5 S.141*, performed by a Russian pianist, Grigory Ginsberg, in 1948. The experimental goals and constraints were facilitated by the solo-instrument piece with a moderate tempo and a duration of less than 3 minutes, which allows contrasting 2-4 bars motifs with variations presented in interwoven manner. 5 right-handed males with no or little musical training participated in the experiment. The MEG signals were recorded with the CTF whole-head system (151 axial gradiometers). The current density reconstruction was performed with CURRY 4.5 source localization software. The time courses of the brain activations were computed by integrating the current density estimates over spherically shaped volumes of interest. The amplitude envelope of the audio signal was used to characterize the rhythmical properties of the excerpts, and to categorize the activation curves. Significant cortical activations showing transient responses following the attack of each note were

identified within the primary and secondary auditory cortex, postcentral gyrus, temporo-parietal junction, anterior and posterior parts of the temporal lobe, supramarginal gyrus, ventro-lateral prefrontal cortex, premotor and motor areas. Significant activations over wider temporal scales, which allow the unfolding of the musical surface and the building-up of the complex system of relations (tonal-harmonic and semantic relations requiring integration of the "cognitive primitives") were identified within the Broca's and its right homologue, the frontopolar cortex, precuneus, orbitofrontal cortex, the anterior and posterior parts of the temporal lobe, and the cerebellum. These areas generally showed higher activation in the right hemisphere. The results suggest that the musical attributes at different temporal scales are processed in distributed and partially overlapping networks: the features of individual notes are analyzed in the pathway up to and including regions within the auditory cortices and motor areas, while higher-order patterns formed by those features are analyzed by networks distributed in the temporal, parietal and frontal lobes.

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Beyond Music Training: Influence of Cerebral Lateralization on Musical Ability

This study examined the relation between musical ability, training, and cerebral lateralization. Ninety-six participants were tested for pitch memory and temporal sensitivity. Participants varied in their extent of formal music training, from a low of 0 years to a high of 25 years. The pitch memory task required that participants discriminate whether the final tone of a sequence was identical to any other tone in the sequence. The temporal sensitivity task required that participants discriminate whether the first or second of two rhythmic patterns was anisochronous. Music training was a better predictor of pitch memory than of temporal sensitivity, with 24% and 5% of variance explained respectively. The correlation between pitch and rhythm tasks was not significant after partialing out training, with less than 1% of variance explained. To examine the association between cerebral lateralization and music ability, we assessed two indexes of hemispheric dominance: handedness and second-to-fourth digit ratio (2D:4D, the ratio between the length of the second and fourth fingers). We found a significant positive correlation between mixed-handedness (i.e., decreased cerebral lateralization) and temporal sensitivity. This correlation remained significant after partialing out training. We did not obtain a significant correlation for 2D:4D and either task. Findings are discussed with regard to hemispheric specialization and a modular view of musical ability.

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Interval and Interval-Class Similarity: Results from a Confusion Study

Undergraduate music majors (N=27) were asked to identify simple musical intervals (minor 2nd to major 7th). Intervals were presented in isolation, using a pseudo-clarinet timbre, in three different presentation modes (ascending melodic, descending melodic, and harmonic) at ten different pitch levels, for a total of 330 experimental trials (11 interval types x 3 presentation modes x 10 pitch levels). Stimuli sounded for either 1.25 sec. for melodic intervals (.5 sec./tone plus .25 sec. inter-tone gap) or for .75 sec for harmonic intervals; subjects then had 8.5 sec. within which to make snap-judgment identifications. The resultant matrices of error rates were analyzed by examination of the raw confusion data and multidimensional scaling (MDS); analysis of variance (ANOVA) was also performed. Examination of the raw confusion data indicated that similar interval-types were more confusable than similarly-sized intervals of different types (e.g., major/minor 2nd vs. major 2nd/minor 3rd) and indicated an increasing tendency to underestimate the size of larger intervals; minor 6ths were hardest to identify. A three-dimensional MDS solution was found, supporting the hypothesis that perceived similarity of simple musical intervals is determined by interactions between interval-type, interval size, and class of dissonance (perfect vs. imperfect consonances vs. dissonances). "Classical" interval class (Forte, 1973) is derivable from the configuration. Two previously published confusion matrices for

musical intervals (Killam, Lorton, & Schubert, 1975; Plomp, Wagenaar, & Mimpen, 1973) were re-analyzed; despite somewhat different methodologies in those studies, the resulting MDS solutions were similar to that of the present study. By contrast, confusion matrices for several different theoretical models (e.g., interval size only, interval type only, acoustical dissonance only) yielded MDS configurations with very different geometric structure.

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Melody Identification: A Multiple Regression Approach

What information do listeners use to "Name that Tune"? This question was investigated in a two-phase experiment with musically inexperienced subjects (averaged less than 3 years of musical training). In phase 1, the participants heard familiar melodies (e.g., 'Frosty, the Snowman') that were played on a note-by-note basis until either they were identified or the 12th note was reached. In phase 2, each of the first 12 notes of the melody was analyzed along a variety of musical dimensions including features related to pitch structure (e.g., tonal function, contour, interval), temporal structure (e.g., relative duration, metrical accent), as well as larger melodic structures (e.g., joint accents, location within phrase, trills, serial position). A series of multiple regression analyses determined which of these factors predicted identification. Three musical factors emerged as consistent predictors of melody identification: notes located at phrase boundaries, notes that completed trills, and metrically accented notes. As well, identification peaked after listeners heard moderate amounts of information (i.e., 5-7 notes). Finally, the subjects' confidence ratings indicated that melody identification is akin to insight problem solving in that the subjects' confidence ratings almost always transitioned from 'having no idea' to 'complete certainty' within one or two notes of information. The major findings were replicated in a second study using subjects with substantial musical training.

These data have numerous implications regarding the processes that listeners use to identify melodies. First, the data suggest that the unit of analysis for melody identification is multi-note sequences (perhaps phrases) rather than individual notes, and that the features of a single note are not as important as the note's relationship to the prevailing musical context. Second, the data urge caution when trying to apply research on music perception to the process of melody identification; that is, musical features that are easily perceived (consonance, diatonicity, interval size) are not necessarily the ones that listeners use to distinguish different melodies. Third, the inclusion of one temporal factor in the regression models contradicts previous claims that temporal information is relatively unimportant for melody identification.

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Anticipated Pleasure of Music-Based on Samples versus Memory

Decision affect theory suggests that people make choices based on the outcome with the greatest anticipated average pleasure. In a previous study applying this theory to music selection, we asked participants to choose from a list of songs which one they would most and least prefer to listen to. After then listening to the least preferred song, they reported a higher degree of pleasure than anticipated, while those who listened to their most preferred song reported a degree of pleasure similar to what was anticipated. This is the same error made by subjects in other studies of this theory. Although all the songs were familiar, predicting pleasure may be different when based on memory versus samples of the songs. The present study was developed to examine predicted and actual pleasure of music-listening when predictions are based on hearing samples of the music.

Thirty college students rated how much pleasure they thought they would get from listening to each of 10 musical selections representing a wide range of styles. A 30-sec sample of each selection was played before it was rated. Participants also indicated which

piece they would most like to listen to and the piece they would least like to listen to. Half the participants then actually listened to the piece they most wanted, and half listened to the piece they least wanted. When the music ended, the participants gave an overall rating of pleasure.

The participants who listened to the most wanted selection rated their pleasure in listening significantly lower than their predicted pleasure. For the group that listened to their least wanted selection, there was no difference in actual and predicted pleasure.

The results of this study were quite different from those of our previous study. When asked to predict pleasure from memory of music, participants were accurate with preferred selections, but underestimated pleasure for non-preferred selections. In the current study, however, when samples of music were used to help participants predict pleasure, they were accurate for the non-preferred selections, but overestimated the pleasure for the preferred selections. This unexpected finding raises new questions about how people assess anticipated pleasure.