

1 – William Aubé (Université de Montréal)

“The effects of emotion on memory: A comparison between music and voices”

William Aubé^{1,2}, Isabelle Peretz^{1,2} & Jorge L. Armony^{1,3,4}

1. International Laboratory for Brain, Music, and Sound Research 2. University of Montreal 3. McGill University 4. Douglas Mental Health University Institute

Previous research has established an effect of emotional expression on memory. Within the visual domain, this effect is emotion-specific, resulting in better memory for fearful faces. In contrast, initial findings for nonlinguistic vocalizations suggested a better memory for all emotional expressions, compared to neutral ones. However, despite the well-established ability of music to elicit emotion, little is known about its effect on memory. In addition, it is possible that music act as a *super-expressive voice*. Using a within-subject design, we tested recognition memory in 50 healthy subjects in the auditory domain. Each participant listened separately to vocalizations and short musical excerpts (happy, fearful, sad and neutral stimuli) during 2 sessions separated by a few days. Results show an emotional effect of music on memory. Higher accuracy was found for both happy and scary music as compared to neutral and sad music. Previous findings with vocal expressions were replicated, with a memory advantage for all emotional expressions. In addition, a correlation between memory performance for music and vocalizations was found, particularly for expressions of threat, and to a lesser degree, for happy stimuli. This suggests a similar memory pattern in both auditory domains which is consistent with the hypothesis that the emotional pathway of vocal emotions is shared with musical emotions, and possibly mediated by the amygdala.

Anne Bolders (Leiden University) - *Cancelled*

“The influence of affective context on loudness judgments and detection threshold for pure tones”

In situations of danger it is adaptive to be sensitive to possible threats in the environment. Increased sensory responsiveness is expected in such situations. Indeed, several studies have demonstrated that being in a highly arousing negative context enhances auditory evoked potentials to neutral sounds. However, little, if any, research has focused on the influence of affective context on auditory perceptual judgment or performance. Therefore in the first study we examined whether loudness judgments are modulated by affective context. Participants were exposed to negative, neutral and positive affective contexts by means of a series of pictures of positive, neutral and negative valence. A few seconds after the picture had appeared on the screen participants were simultaneously exposed to a 440 Hz tone (500 ms) at one of 10 sound



pressure levels (SPLs) varying between trials from 50 to 77 dB(A). Loudness estimates were collected after each trial by means of free magnitude estimation. Results show no main effect of picture valence on loudness. However, when analysis was restricted to the 3 lowest and highest SPLs only, negative valence resulted in heightened loudness (compared to neutral valence) at the lower SPL levels and in lowered magnitude at the higher SPL levels. Positive valence resulted in heightened loudness (compared to neutral affect) at lower SPL levels, but had no effect at high SPL levels. These findings suggest that the affective context modulates loudness judgment, but that this effect is dependent on SPL. Therefore in a second study we focused on the influences of affect on detection of low SPL sounds. Findings in the visual domain do suggest that affect changes sensory sensitivity for weak stimuli. Phelps et al. (2006) showed that fearful faces compared to neutral faces enhance contrast sensitivity for subsequently presented neutral visual stimuli. In the second study we investigated whether enhancement of sensory sensitivity by visual affective cues generalizes to the auditory domain. Auditory detection thresholds (80% accuracy) for 1 kHz tones in constant background noise (40 dB (A)) were taken as measure of sensory sensitivity. The thresholds were determined by means of an adaptive staircase tracking method in a two-interval forced-choice task. Both intervals of one trial were preceded by either a fearful or a neutral face. Detection thresholds in noise were compared between conditions in which detection was preceded by fearful faces or neutral faces. These findings contribute to our understanding of the influence of affective cues on nonaffective sensory processing.

2 – Elodie Cauvet (INSERM CEA)

“Effect of constituent structure complexity in spoken language and in music”

Elodie CAUVET¹, Nobuko HARA¹, Anne-Dominique DEVAUCHELLE¹, Denis LE BIHAN², Stanislas DEHAENE¹, Christophe PALLIER¹

1. INSERM-CEA-Collège de France-Université Paris 11, Cognitive Neuroimaging Unit, Neurospin center, France 2. CEA-Collège de France-Université Paris 11, Neurospin center, France

Syntactic theories postulate that utterances from human language are not simple strings of words but can be analyzed as structures of nested constituents. Similarly, it has been argued by Lerdahl and Jackendoff (1983), in their Generative Theory of Tonal Music, that musical stimuli could be described as having a constituent structure. The present experiment was designed to search for brain areas that encode the syntactic structures of music or language stimuli. We reasoned that such areas should be sensitive to the amount of structure in the stimuli, defined as the size of the constituents. We created stimuli having various degrees of structure by concatenating constituents of various size extracted from oral sentences and from pieces of music.

The results with spoken language essentially replicate those observed in a previous reading experiment where activation increased with constituent size in a network of regions comprising the left inferior frontal gyrus (pars orbitalis and triangularis), the anterior temporal lobes (bilaterally) and the left temporo-parietal junction. Conversely, several regions, outside the classical language areas, showed higher activation levels when the amount of structure decreased: the middle frontal gyri, the anterior cingulate, the precuneus and the inferior parietal gyri. With musical stimuli, increasing levels of structure yielded increases of activation in three small spots, located the left anterior STS (a region also sensitive to structure in language), the left precentral gyrus and the right superior temporal sulcus. Regions sensitive to decreasing amount of structure were

much more extended and matched those observed for language. It is possible that this set of regions is sensitive to the predictability of the stimuli, irrespective of the domain. Consistent with this idea, musicians showed stronger (negative) effects of musical structure in some of these regions than non-musicians.

3 – Jean-Pierre Chartrand (Université de Montréal)

“Effects of auditory expertise on voice-selective cortex”

Chartrand, J.P.¹, Bélizaire, G.¹, Peretz, I.¹, & Belin, P.^{1,2}

(1) *International Laboratory for Brain, Music and Sound (BRAMS), University of Montréal, Montréal, Canada.* - (2) *Voice Neurocognition Laboratory, Department of psychology & Center for cognitive neuroimaging, University of Glasgow, Glasgow, UK*

The cerebral regions involved in face perception as well as expert object recognition have been much studied, leading to a large debate about the modularity of face perception. In the auditory domain, the human voice can be considered as an “auditory face”, a most prominent and significant auditory stimulus in our auditory environment. The existence of ‘temporal voice areas (TVA)’ analogous to the face-selective areas of visual cortex suggests that analogous questions on the domain specificity of voice perception and its role in expert auditory recognition can be asked. The goal of this study was to assess the extent to which the TVA are recruited in auditory experts by (non-vocal) stimuli of expertise.

Sixteen healthy participants (8 bird experts; 8 guitar makers) were recruited based on their respective expertise in sound source recognition. They first performed four auditory memory and discrimination tasks using different categories of auditory stimuli (environmental sounds, birdsongs, guitar tones, human voices). Afterwards, they were scanned on a 3-Tesla scanner while 1) passively listening to vocal and non-vocal sounds (10-minutes “voice-localizer” scan) 2) performing a one-back auditory task with birdsongs, guitar sounds and vocal sounds presented in an event-related design. fMRI analyses were performed using SPM 5 and marsbar.

At the behavioural level, auditory expertise resulted in a significant interaction between expertise group and stimulus category: bird experts were better at discriminating birdsongs than guitar sounds, and the converse pattern was observed in guitar makers. Individual voice-selective maps were created from the first fMRI run (vocal vs non-vocal). fMRI data revealed a corresponding interaction ($p < 0.05$ corr.) between expertise group and stimulus category in the left TVA with greater response of voice-selective cortex to the category of expertise.

These results indicate that expertise with an auditory category enhances response of voice-selective cortex to (non-vocal) stimuli of expertise. The left-lateralization of this effect could be related to verbal strategies used by experts during sound categorization, such as verbal labeling of individual sound sources. These results reinforce the suggestion, coming from visual studies, that face- and voice-selective cortices could in fact reflect expertise - or prolonged exposure- with those stimulus categories, rather than pure face- or voice-selectivity per se.



4 – Andy Christen (University of Geneva)

“Dynamics of local field potentials within human amygdala and orbitofrontal cortex in response to attended and unattended emotional prosody”

Andy Christen^{1,2}, Margitta Seeck³, & Didier Grandjean^{1,2}

1) *Neuroscience of Emotion and Affective Dynamics laboratory, Department of Psychology, University of Geneva, Geneva, Switzerland.* 2) *Swiss Center for Affective Sciences, University of Geneva, Geneva, Switzerland.* 3) *Department of Neurology, Hôpitaux Universitaires Genevois, Geneva, Switzerland.*

Detection of potentially relevant events in the environment may occur at different levels of processing, including processes being engaged relatively independently of voluntary attention and other being dependent on voluntary attention and task demand. The purpose of this study was to investigate how endogenous and exogenous processing of emotional prosody might temporally modulate brain responses. Local field potentials of a young woman suffering from chronic and pharmaco-resistant epilepsy were recorded in order to investigate amygdala and orbitofrontal (OFC) neuronal responses. In order to manipulate spatial attention orthogonally to emotional prosody, we used a dichotic listening paradigm, in which two neutral and/or angry pseudo-words were presented simultaneously on both ears. The task required the participant to identify the gender of the speaker on the side where her attention was directed. Continuous wavelet transform analysis (CWT) were performed in the right amygdala as well as in the right medial OFC. We hypothesized that processes involved in spatial attention would modulate brain activity in these areas in response to emotional prosody compared to neutral one. Our main results showed that exogenous processing of angry prosody compared to neutral prosody induced a sustained increase of neuronal response, at the onset of the stimulus, in low frequency range (i.e theta) and in the alpha band in both amygdala and medial OFC; these early responses being followed by an enhancement at the offset of the stimulus in the theta (amygdala only) and beta frequency ranges (within both amygdala and OFC). In contrast, our data revealed an early response in the beta frequency range only within the medial part of OFC for the voluntary processing of angry prosody compared to neutral one. Thus, the same contrast brought to light a post-offset enhancement in the theta frequency range followed by a massive and later response within the gamma range in the OFC. Taken together, these results highlight that neuronal assemblies of the amygdala and the medial OFC are responsible for encoding the emotional value of a stimulus by underlying early relevance-detection processes, relatively independent of voluntary attention, as well as later top-down mechanisms dependent of attention.

5 – Marion Cousineau (Université Paris Descartes, ENS Ulm)

“A special status for sequences of pitch”

Cousineau Marion¹, Demany Laurent² and Pressnitzer Daniel¹

1) *Laboratoire de Psychologie de la Perception (UMR CNRS 8158), Université Paris-Descartes & Département d'Etudes Cognitives, Ecole Normale Supérieure Ulm, Paris, France* 2) *Laboratoire Mouvement, Adaptation, Cognition (UMR CNRS 5227), Université de Bordeaux, France*

In order to understand speech or appreciate music, listeners have to process patterns of sounds that vary along many perceptual dimensions. Sequences of pitch seem to play a particularly important role: they support intonation for speech and melodies for music. Pitch of single sounds



is encoded accurately over a wide range, so this could be a first reason for a central role of this dimension. However, there may be additional mechanisms specific to sequence processing. Here, we investigated the ability of normal-hearing listeners to process sequences of sounds varying either in pitch or in loudness. The individual sounds used in the sequences were 200-ms harmonic complex tones. In the pitch conditions, fundamental frequency was varied. We used binary sequences, for which only two possible fundamental frequencies were possible and chosen randomly for each note of the sequence. In the loudness condition, overall level was varied, again with binary sequences. Importantly, the fundamental-frequency differences and level differences were adjusted for each listener and condition, in order to produce a fixed level of discriminability. This made it possible to assess sequence processing per se, independent of the accuracy of sound encoding. Same/different judgments were collected, for which two sequences of up to eight sounds each had to be compared. Results showed that pitch sequences were processed more effectively than loudness sequences, but only when the sequence elements included low-rank harmonics which could be at least partially resolved in the auditory periphery. The effect of roving and transposition was also investigated. These manipulations reduced overall performance, especially transposition, but an advantage for pitch sequences was still observed. We interpret these results by suggesting that pitch contour may be coded by automatic frequency-shift detectors, available for pitch sequences but not loudness sequences. These findings also have implications for clinical populations such as hearing-impaired listeners, or cochlear implant listeners, whose ability to resolve harmonics can be severely reduced.

6 – Nathalie Gosselin (Université de Montréal)

“Statement / Question Categorization in Congenital Amusia”

Nathalie Gosselin, Sean Hutchins, Isabelle Peretz

*International Laboratory for BRAin Music and Sound (BRAMS), Department of Psychology,
University of Montreal*

Congenital amusia (or tone deafness, as it is commonly called) involves problems in pitch discrimination. Although this is most salient in music-related tasks, pitch also plays a central role in linguistic prosody. In particular, the distinction between sentences spoken as a question or as a statement relies heavily on the pitch contour of its final syllables. Prior studies have differed on whether amusia can cause difficulties in discriminating between statements and questions (Ayotte, Peretz, & Hyde; 2002; Patel et al., 2008). In this experiment, we examine how amusics categorize small differences along the statement / question continuum. The stimuli were sentences which had different prosodic interpretations created by manipulating the pitch height of the final syllables. Eleven different final syllable pitch heights were used, creating a prosodic continuum with equal steps varying between clear statement and clear question. Amusic and control participants were asked to listen to each and judge whether it was an example of a statement or a question. Logistic regression analyses were used to compare amusic and control groups. Results showed that, while amusics and controls divided between statements and questions at the same boundary point, amusics showed less consistency in their judgments, with more errors overall. These results help to clarify earlier studies, and suggest that amusics and controls categorize statements and questions according to the same rules, but amusics do so less accurately in general.



“Spatial Frequencies Mediating Music Reading”

Zakia Hammal, Frédéric Gosselin, Isabelle Peretz and Sylvie Hébert

International Laboratory for BRAin Music and Sound (BRAMS), University of Montreal

The purpose of this study was to examine Spatial Frequencies (SFs) mediating music reading compared to text reading. The SFs Bubbles technique (Willenbockel et al., 2009), which consists in randomly sampling multiple SFs simultaneously on each trial, was used. A set of 70 piano excerpts selected from the unfamiliar piano repertoire was used for music reading and 50 sentences from MNRRead Acuity Charts were used for text reading. The visual size of each letter and note was about 0.34° . Five pianists and five naïve observers took part in the experiments. The percentage of correctly produced pitches and ‘ascii code’ was used as a performance measure for music and text reading respectively. To find out which SFs drove the participants’ correct responses for music and text reading, a multiple linear regression was performed. A statistical test (Chauvin et al., 2005) was then used to determine thresholds that selected the diagnostic SFs for accurate performance. The music reading results showed a significant SFs band (from 1 to 1.7 cycles per note (cpn)) peaking at 1.19 cpn, compared to two SF bands for text reading: the first SFs band (from 1.08 to 1.3 cycles per letter (cpl)) peaking at 1.2 cpl and the second SFs band (from 1.6 to 2.6 cpl) peaking at 1.8 cpl. In a control experiment, five new pianists were instructed to play the set of 70 excerpts, first sampled with the obtained diagnostic filter for music reading, and then without sampling. Pianist performances with the diagnostic filter (94%) were comparable (96%) to those without filtering ($P > 0.05$). The present findings show that music reading is mediated only partly by SF bands mediating text reading, which may explain why in some cases, difficulties in music reading are not necessarily accompanied by difficulties in text reading.

8 – Marina Korsakova-Kreyn

“Affective Responses to Tonal Modulation to Selected Steps”

Marina Korsakova-Kreyn; W. Jay Dowling; James C. Bartlett

The study used bipolar adjective scales to measure the intensity of affective responses and perceived tension to modulating stimuli. Three steps were selected as targets of modulation: the Subdominant (5), Dominant (7), and step 8. Each step was represented by eight progressions that were balanced for melodic contours of the soprano and bass lines, and by eight real music excerpts. All stimuli were in the major mode. Sixty-five participants, 49 females and 16 males, heard two sets of stimuli: 24 eight-chord progressions written by the principal experimenter and 24 brief real music excerpts selected from classical piano compositions. The results indicate differentiated affective responses to the different modulations and their dependence on key proximity. Participants perceived modulations to the relatively distant step 8 as the most tense, compared to the close modulations to the Subdominant (5), Dominant (7). This association between increase in key proximity and increase in perceived tension is in agreement with a theoretical model of key proximity based on the circle of fifths. In addition to the higher tension ratings, modulations to step 8 were perceived as “colder” and “darker” than modulations to the



Subdominant (5) and Dominant (7), thus showing a link between negative synaesthesia-related ratings and higher tension ratings.

Modulations to the Dominant (7) were perceived as “happiest,” and modulations to the Subdominant (5) were heard as “weaker” than modulations to the Dominant. These findings are associated with asymmetry in perceived pitch proximity related to the direction around the circle of fifths, and are in agreement with musicological research recognizing a subdominant sphere as “weaker” than the dominant region. This finding also provides corroborating evidence to previous studies showing asymmetry in perceived key proximity; the asymmetry is related to clockwise motion around the circle of fifths versus counterclockwise motion. The listeners demonstrated sensitivity to contour patterns in modulations to the Subdominant (5) and Dominant (7): modulations with simultaneous upward motion in soprano and bass lines were perceived as “happier” and “brighter” than modulations with the simultaneously falling soprano and bass lines. However, the contour patterns did not affect responses to the relatively distant step 8, which suggests that the effect of key proximity overrides the effect of contour patterns. Overall, the results demonstrated a general similarity of responses in the real music excerpts and the harmonic progressions.

9 – Marie-Andrée Lebrun (Université de Montréal)

“Congenital Amusia in childhood”

Lebrun, M.A., Moreau, P., McNally, A., Migneault-Guertin, G., Peretz, I.

International Laboratory for BRAin Music and Sound (BRAMS), Department of Psychology, University of Montreal

We report here the first documented case of congenital amusia in childhood. Congenital amusia is a developmental disorder characterized by impaired pitch perception that compromises music perception and production. Until today, this disorder has been documented in the adult population. This case study presents AS, a ten-year-old girl who was referred to us by her choir director for persisting difficulties in singing. We tested her with a new version of the Montreal Battery for the Evaluation of Amusia (MBEA) for children that confirmed her severe problems in discrimination and memory of melodies. In addition, she cannot detect pitch changes that are smaller than a quarter of a semitone, whereas a large majority of children of her age can. Moreover, AS' pitch production is severely impaired, while her contour production is normal. AS shows a deficit in most basic musical abilities that can not be explained by prior brain lesion, hearing loss, cognitive deficits, socioaffective disturbance, or lack of environmental stimulation. The music-processing difficulties encountered by the child seem to result from problems in fine-grained discrimination of pitch.



10 – Julie Mercier (McGill University)

“Individual Differences in Executive Function and Spoken Word Recognition”

Mercier, J., Pivneva, I., Haigh, C., & Titone, D.

Department of Psychology, McGill University

Spoken language processing requires that individuals map a temporally unfolding and noisy acoustic signal onto stored knowledge about words in memory. Given the high degree of phonological overlap among words within a language, this process is not trivial in that listeners must simultaneously suppress partially activated unintended candidates and enhance activation of the intended word. We investigated whether individual differences in executive function affect the time course of spoken word processing using the visual world paradigm. Participants listened to spoken words (e.g., bathtub) and looked at pictures including the target, a word onset competitor (e.g., bagpipes), and unrelated filler pictures, while their eye movements were monitored. One group (n = 23) had no advance training with the picture names, whereas another group (n = 21) did have advance training. All participants looked more at competitor pictures than at other non-target pictures; however, executive function measures in the two groups differentially correlated with competitor effects. Individual differences in executive function correlated with within-trial estimates of competitor effect only for group that was not trained on the pictures, and thus for whom strategic effects were less likely. Better working memory was associated with less competitor suppression, or a broader activation of lexical candidates prior to the phonemic divergence point from which the target and competitor words could be disambiguated. Furthermore, we found that good inhibitory function was associated with more efficient competitor suppression at or following the divergence point. Importantly, these correlations were not due to individual differences in verbal intelligence. Thus, individual differences in executive function affect the temporal dynamics of spoken word recognition, especially under conditions that are most reflective of natural language processing.

11 – Dawn Merrett (University of Melbourne)

“Using Music to Speak After Stroke”

Dawn Merrett^{1,3}, Isabelle Peretz², Graeme Jackson^{1,3}, Sarah Wilson^{1,3}

1) The University of Melbourne 2) International Laboratory for BRAin Music and Sound (BRAMS), Department of Psychology, University of Montreal 3) Florey Neuroscience Institutes

Introduction: Previous research has shown that singing therapy may facilitate language recovery in individuals with language disorders, such as non-fluent aphasia, after stroke. Despite some evidence for the efficacy of singing, the mechanism(s) by which it might promote language recovery are still uncertain. To probe these issues, this project will investigate the influence of intensive singing training on brain organization and on music and language outcomes in a group of neurologically-healthy individuals and a group with non-fluent aphasia.

Methods: Participants will be given questionnaires to determine their hand preference, their music and language background, medical history, and mood. Additional assessments will include estimation of IQ, musical abilities, memory, attention, and verbal generation. Participants with



language impairment will also undergo a detailed investigation of language and speech function to fully characterize their language difficulties. Behavioural assessments will be used to characterize music and language abilities and functional Magnetic Resonance Imaging will be used to assess patterns of neural activation both before and after singing training. Thirty hours of standardized singing training will be delivered over six weeks using a digital video disc.

Results: The pre- and post-training behavioural results for a pilot participant will be available by the time of presentation.

Discussion: This project will allow valuable conclusions to be made regarding the efficacy of singing training for language rehabilitation. More generally, this research will provide insight into (1) the interaction of music and language in the brain, and (2) the mechanisms of language reorganization after brain injury.

12 – Geneviève Mignault (Université de Montréal)

“Congenital amusia in children: An electrophysiology study”

Geneviève Mignault, Patricia Moreau, Isabelle Peretz

International Laboratory for Brain, Music and Sound (BRAMS), University of Montréal, Montréal, Canada.

Congenital amusia is a disorder preventing individuals from developing basic musical skills. It has been demonstrated that congenital amusia affects mainly the perception of pitch and that it can be traced down to an abnormal P3 brain response elicited by pitch changes smaller than a semitone. However, it has also been demonstrated that the amusic brain processes these same pitch differences accurately at a preconscious level, as reflected by the event-related mismatch negativity (MMN). These results, obtained with adult amusics, suggest that the pitch deficit found in congenital amusia may not originate from a neural anomaly in the auditory cortex but rather later, along the temporo-frontal auditory pathway. The brain responses to pitch changes in congenital amusia have not yet been studied in children. In this study, we examined the brain responses to pitch in amusic children. First, we examined these responses with a MMN paradigm, in order to assess the pre-conscious level. We further examined the conscious detection of pitch changes with an oddball task paradigm. We compared 8 amusic children with 10 normal children. The results reveal a pattern of electrical brain responses that is comparable to the one obtained in adult amusics. That is, we found an abnormal P3 elicited by pitch changes smaller than a semitone, but a normal mismatch negativity for the same pitch changes. This indicates that the neurofunctional origins of the pitch deficit found in congenital amusia in children are similar to those observed later in life, at the adult age.

13 – Maxime Pelland (Université de Montréal)

“Familiar voice perception in noisy environment”

Pelland, M. (1), Vannasing, P. (2), Guillemot, J.-P. (3), Lepore, F. (1)

(1) Université de Montréal, (2) CHU Sainte-Justine, (3) Université du Québec à Montréal

Familiar voices are special in that they are better understood and recognized in noisy environments. Moreover, a recent research shows that voice familiarity is reflected in the



amplitude of the mismatch negativity. However, it is still unknown how the mismatch negativity for familiar voices is affected by background noise. The goal of the present study is to investigate the effect of noise presented in free field on the mismatch negativity elicited by familiar voices. Two tasks are used to control for voice perception in noise. In the first one, participants have to recognize voices from modified piano tones in a two alternative forced choice presented at different sound intensities. The threshold for this task is obtained for each participant using a psychometric curve. In the second control task, participants have to identify a familiar voice amongst unfamiliar voices. An oddball paradigm is used to elicit the mismatch negativity. Its rare stimuli consist of a familiar and a matched unfamiliar voice. Preliminary results suggest that, when signal to noise ratio is low (hard to perceive voices), familiar voices present a different time course compared to unfamiliar voices. However, when signal to noise ratio is high, there are no perceivable differences.

14 – Julie Peron (Université Rennes 1, France)

“Major Depressive Disorder Skews the Recognition of Emotional Prosody”

Julie Péron^{123#}, Sarah El Tamer^{1#}, Didier Grandjean³, David Travers¹⁴, Dominique Drapier¹⁵, Marc Vérin¹² and Bruno Millet¹⁵

¹URU-EM 425 Comportement et Noyaux Gris Centraux, Université Rennes 1, France. ²Clinique Neurologique, Hôpital Pontchaillou, CHU de Rennes, France. ³Neuroscience of Emotion and Affective Dynamics, Department of Psychology, University of Geneva, Switzerland. ⁴Service des Urgences, Hôpital Pontchaillou, CHU de Rennes, France. ⁵University Department of Psychiatry, Rennes, France. #These authors contributed equally to this work.

Background: Major depressive disorder (MDD) is associated with abnormalities in the recognition of emotional stimuli. MDD patients ascribe more negative emotion but also less positive emotion to facial expressions, suggesting blunted responsiveness to positive emotional stimuli. To ascertain whether these emotional biases are modality-specific, we examined the effects of MDD on the recognition of emotions from voices using a paradigm designed to capture subtle effects of biases.

Method: Twenty-one MDD patients and 21 healthy controls (HC) underwent clinical and neuropsychological assessments, followed by a paradigm featuring pseudowords spoken by actors in five types of emotional prosody, rated on continuous scales.

Results: Overall, MDD patients performed more poorly than HC, displaying significantly impaired recognition of fear, happiness and sadness. Compared with HC, they rated fear significantly more highly when listening to anger stimuli. They also displayed a bias toward surprise, rating it far higher when they heard sad or fearful utterances. Furthermore, for happiness stimuli, MDD patients gave higher ratings for negative emotions (fear and sadness). A multiple regression model on recognition of emotional prosody in MDD patients showed that the best fit was achieved using the Pessimistic and Suicidal thoughts items of the Montgomery-Asberg Depression Rating Scale.

Conclusions: Impaired recognition of emotions would not be specific to the visual modality but would also be present when emotions are expressed vocally, this impairment being related to depression severity. MDD would skew the recognition of emotional prosody toward negative emotional stimuli and the blunting of positive emotion would not be specific to the visual modality.



“The Effect of Performance Features on the Psychophysiological Responses of Listeners”

David Sears¹, Mattson Ogg³, Manuela Marin², Mitchel Benovoy⁴, Stephen McAdams¹

¹ CIRMMT, Schulich School of Music, McGill University, ² Department of Psychology, Goldsmiths College, University of London, ³ Department of Psychology, McGill University, ⁴ CIRMMT & CIM, Department of Electrical and Computer Engineering, McGill University

In considering the effect of music on the emotional experiences of listeners, two methodological obstacles impede progress in emotion research: 1) the ability to provide a potentially objective measure for the study of emotions felt by listeners, and 2) an analytical technique that can account for how emotions change dynamically over time. In Spring 2009, Ogg attempted to provide solutions to these obstacles by adopting psychophysiological measures that tap into bodily responses reflecting activity of the sympathetic nervous system. Using the acoustic stimuli and psychophysiological data Ogg acquired, we sought to determine the effect of performance features (dynamics and tempo variation), both between and within the musical excerpts, on the physiological responses of listeners.

In 2009, Ogg presented 20 musically-trained subjects with 19 Romantic piano stimuli in small ternary form lasting between 50-90 seconds. In a preliminary study, subjects clustered the stimuli across two axes of the dimensional emotion space: valence (positive-negative) and arousal (excited-calm) (Russell, 1980). During the main experiment, Ogg recorded three psychophysiological measures: galvanic skin response (GSR), heart rate (HR), and facial electromyography (EMG), and then conducted statistical analyses of the mean psychophysiological measures across all subjects to determine if each of the quadrants of Russell’s emotion space possessed specific psychophysiological profiles. Although the initial analyses did not capture the dynamic emotional experience of listeners over time, they did indicate the reliability of psychophysiological measures for valence (primarily in EMG) and arousal (primarily in GSR and HR).

In order to account for variations in each of the biosignals both between and within excerpts, we extracted expressive performance features from each of the acoustic stimuli. Clarke (1999) has suggested that these features are important for conveying structural and emotional information to the listener, and several researchers have attempted to model the rule systems that govern expressive performance parameters (Todd, 1985; Palmer, 1996). Gomez and Danuser (2007) have also suggested that tempo, accentuation, and rhythmic articulation are the features most strongly correlated with psychophysiological measures.

To maintain the ecological validity of the stimuli, recordings were taken from acoustic performances (rather than using mechanical midi performances). Although such a decision reflects a desire to study the effects of “real” music on listeners, it also poses the significant challenge of extracting performance features from the acoustic signal. In order to derive loudness information directly from the audio file, we employed Moore & Glasberg’s loudness model (1997), which accounts for outer- and inner-ear filtering, frequency warping into a cochlear-like frequency distribution, frequency masking, and temporal masking. Moore & Glasberg’s model therefore attempts to provide a perceptually valid approach to modeling loudness. To obtain tempo variation information, we employed Simon Dixon’s BeatRoot software (2001), which provides a means of manually extracting the beat from audio at an experimenter-selected metrical level.

Between-excerpts analyses revealed a significant correlation between the mean performance features and the mean GSR and HR signals for each excerpt, suggesting that performance



features modulate the arousal responses of listeners. To determine the potential effect of variations in performance features on biosignals within excerpts, we applied a time series autoregressive model to the averaged psychophysiological responses. We additionally considered the effect of musical form (ABA') on both the performance and the psychophysiological measures.

16 – Mary Elizabeth Sutherland (Montreal Neurological Institute)

“Maturation of Auditory Cortex through Adolescence and its Relationship to Detection of 2-Hz Frequency Modulation”

Mary Elizabeth Sutherland^{1,2}, Robert Zatorre^{1,2}, Pierre-Yves Hervé³, Kristina Martinu¹, Gabriel Leonard¹, Kate Watkins⁴, Tomas Paus^{1,3}

1) Montreal Neurological Institute, McGill University, 2) BRAMS Laboratory, 3) Brain and Body Centre, University of Nottingham, UK, 4) Department of Experimental Psychology, University of Oxford

Adults show great variation in their aptitude for different auditory tasks, such as discriminating between foreign speech-sounds. Previous research has demonstrated that structural features of auditory cortex can predict auditory abilities; we are interested in the maturation 2-Hz frequency-modulation (FM) detection, a task thought to tap into mechanisms underlying language ability. We hypothesized that an individual's FM threshold will correlate with greater grey-matter density in left Heschl's gyrus (HG), and that this correlation will change through adolescence. To test this hypothesis, we collected anatomical magnetic resonance imaging data from participants who were tested and scanned at three time points: at 10, 11.5 and 13 years of age (n=45). Participants judged which of two tones contained FM; their threshold was calculated based on the geometric mean of several trials. Using voxel-based morphometry, we found that FM threshold was significantly correlated with grey matter in left HG pre-puberty (lower thresholds were associated with greater concentration of grey matter); this correlation weakened after the onset of puberty (ages 11 and 13). Our results confirm that the structure of the auditory cortex can predict temporal processing abilities, in particular that grey-matter density in left HG can predict 2-Hz FM detection threshold. This ability is dependent on the processing of rapidly changing sounds, a skill believed necessary for speech processing. The weaker correlation between these regions and 2-Hz FM processing at age 11.5 and 13 may indicate the effect of maturational processes that occur during adolescence on this particular brain-behaviour relationship.

17 – Wiebke Johanna Trost (University of Geneva)

“The physiological signature of musical emotions”

Wiebke J. TROST^{1,2}, Carolina LABBÉ RODRIGUEZ³, Patrik VUILLEUMIER^{1,2}

1) Department of Neuroscience, University Medical School, University of Geneva, Switzerland, 2) Swiss Center for Affective Sciences, University of Geneva, 3) Department of Psychology, University of Geneva

Music is able to induce strong emotional reactions which manifest themselves in changes in physiological processes. To elucidate the type and dynamics of these physiological responses to music, the present study aimed at inducing a broad range of emotions typically evoked by music and recording the concomitant bodily responses. We based our study on a psychological model (Zentner et al., 2008) that proposes nine different emotion categories (wonder, transcendence,



tenderness, nostalgia, peacefulness, power, joy, tension and sadness) inducible by music. Furthermore we were interested in studying the specific influence of the tempo on musical emotions.

In a block design participants listened to excerpts of classical music and evaluated their stimulus-evoked emotions according to the 9-emotion category model immediately after each excerpt. During stimulus presentation respiration and cardiac activity were recorded. We calculated mean respiration (RR) and heart rates (HR) and correlated these measures with the subjective evaluations of each subject as well as with the tempo in the music.

Our results show that each emotion category of the model is indeed correlated with the tempo. Categories that are positively correlated with tempo induce an increased respiration rate, and involve higher arousal. When controlling for the effect of tempo, several of these relations resist, providing evidence that tempo is not the driving force for emotion induction. Further, when controlling for order effects, we also find positive correlations for cardiac activity, and these involve pleasant and arousing categories.

18 – Anna Zumbansen (Université de Montréal)

“Melodic Intonation Therapy for aphasia rehabilitation: Where are we now?”

Background: Speech-language pathologists are increasingly required to demonstrate that their practice is based on scientific evidence. In 1994, the American Academy of Neurology regarded Melodic Intonation Therapy (MIT) as the most promising avenue for aphasia rehabilitation. Based on observations that some patients were able to produce words when singing despite a very poor performance in speaking, Albert, Sparks, & Helm (1973) had proposed the MIT technique to improve propositional speech in individuals with aphasia. MIT is a structured protocol and uses intonation patterns that exaggerate the normal melodic content of short sentences. Almost 40 years later, however, MIT's effectiveness is still unsettled. In this study, two simple but essential questions were formulated: 1) What exactly constitutes the formal protocol of MIT, and 2) What are the evidences of its effectiveness?

Method: To answer the first question, a literature search was undertaken in the medical database CINAHL, EMBASE, MEDLINE, PubMed, and PsycINFO, from year 1973 to year 2009. Cross-referencing was used to increase the number of articles. Key words used were “melodic intonation therapy”, and “aphasia AND music therapy”. Languages English and French were included. To answer the second question, the same protocol was used but with the keywords “melodic intonation therapy AND effectiveness” and “melodic intonation therapy AND evidence”.

Results: Since their original publication, MIT authors have proposed several versions of their protocol, some of them being contradictory. For instance, the use of pictures or written material is either encouraged or strongly discouraged. Moreover, when adapted by other authors to different languages, modifications that are not solely linguistic adaptations were added. For instance, the rhythm-stress pattern of the sentence is tapped out by the patient's left hand in the American protocol in order to “stimulate the undamaged right cerebral hemisphere”, whereas this tapping can be realized with any part of the body in the French protocol. Nevertheless, in general MIT studies support its effectiveness in improving the speech output of individuals with Broca's aphasia. It remains unclear, however, if it is successful for the rehabilitation of auditory comprehension deficits. Furthermore, there is no consensus about the brain mechanisms involved, that is, if MIT engages right-hemisphere regions or, rather, reactivates left-hemisphere perilesional structures. Finally, there is very little data on the effect of MIT on quality of life.



Discussion: Several factors could account for the inconsistent findings observed with MIT and can be classified in two broad categories, namely, patient-related variables (e.g., lesion size and localization, post-onset time, prosodic properties of native language, level of music training), and therapy-related variables (MIT version implemented, frequency and number of MIT sessions).

Conclusion: Many different protocols exist under the MIT label. Although MIT appears to be effective for Broca aphasia rehabilitation, rigorous studies combining brain imaging techniques with formal protocols are needed to increase the strength of the evidence and to put forth new hypotheses about the mechanisms and brain regions involved in this promising therapeutic approach.

Albert, M. L., Sparks, R.W. & Helm, N. A. (1973). Melodic intonation therapy for aphasia. *Archives of Neurology*, 29, 130–131.

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