The Neurosciences and Music Conferences. An overview 2011-2017.

Part two: Schematic surveys.

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Part two: Schematic surveys.

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A survey of the 47 papers in
The Neurosciences and Music Conference IV in Edinburgh 2011. Learning and Memory. **2 - 17**
Annals of the New York Academy of Sciences 2012, vol. 1252.

A survey of the 34 papers in
The Neurosciences and Music Conference V in Dijon 2014. Cognitive Stimulation and Rehabilitation. **18 - 29**
Annals of the New York Academy of Sciences 2015, vol. 1337.

A survey of the 47 papers in
The Neurosciences and Music Conference VI in Boston 2017. Music, Sound and Health. **30 - 41**
Annals of the New York Academy of Sciences 2018, vol. 1423.

The surveys present, for each paper:

Abbreviated title with page numbers, Categories of investigation and Aim of the study

Musical material, Cultural references, Technology and Procedure

Main focus of interest and Conclusion

The Neurosciences and Music IV: Learning and Memory. Conference June 9-12, 2011 at The University of Edinburgh, Scotland, UK.

A survey of the 47 papers in the conference proceedings:
***Annals of the New York Academy of Sciences*, Volume 1252 (2012)**
edited by Katie Overy, Isabelle Peretz, Robert J. Zatorre, Luisa Lopez, and Maria Majno

Contents:

The survey presents, in brief and schematic form, for each paper:

Abbreviated title as indicated in the conference proceedings, with page numbers.
Categories of investigation
Aim of the study
Musical material and Cultural references
Technology and Procedure
Main focus of interest
Conclusion

Recurrent abbreviations: EEG: Electroencephalography. MEG: Magnetoencephalography. MMN: Mismatch Negativity. PET: Positron Emission Tomography. fMRI: functional Magnetic Resonance Imaging. MRI: Magnetic Resonance Imaging. DTI: Diffusion Tensor Imaging. CR: Cultural reference

EXPERIMENTAL METHODS FOR WORKING WITH CHILDREN (1-4)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. McMahon et al. (17-24) Auditory brain development in premature infants: the importance of early experience Cat. 9: Child development	To suggest ways to enhance the quality control and type of sounds delivered to preterm newborns in neonatal intensive care units (NICU)	Recommendations: Play recordings of the mother's voice inside the incubator. Expose the preterm infants to vocal music, such as lullabies. Instrumental pieces are not recommended. CR: Neutral	Recommendations: Avoid or dampen unpredictable noise coming from ventilators, cardiac monitors, infusion pumps, pagers and alarms. Measure noise levels at the bedside routinely	Preterm newborns are at a critical period for auditory development, and are especially sensitive to noise. Positive auditory experience is essential for early brain maturation and healthy neurodevelopment	Recommendations: Place emphasis on making the NICU a conducive environment for positive auditory experience. Protect the preterm infants from potentially adverse noise
2. Trainor (25-36) Musical experience, plasticity and maturation: issues in measuring developmental change using EEG and MEG Cat. 9: Child development	To discuss and exemplify EEG and MEG methods for studying musical development, including the measurement of Event-Related Potentials (ERP) and Mismatch Negativity (MMN)	1) MMN studies: Changes in pitch, duration and tonal patterns. Melodies in guitar or marimba timbre. 2) One ERP study: Violin, piano, and sinus tones. 3) Studies of evoked beta activity: Steady beats. CR: Neutral, Western	EEG and MEG: measurement of ERP, MMN, and changes in evoked beta-band and gamma band oscillations in response to auditory stimuli. MEG: techniques for localizing activity in specific areas of the brain	To test and evaluate different EEG and MEG methods, including the elimination of artifacts in experimental data, machine-learning approaches, and voxel-based waveform analysis	EEG and MEG data can contribute substantially to the understanding of musical development and the effects of musical training. New data analysis techniques offer great promise for future studies
3. Trehub (37-42) Behavioral methods in infancy: pitfalls of single measures Cat. 9: Child development	To outline and discuss the principal behavioral methods used to study music processing in infancy	Discussion of numerous studies and stimuli, including pure tones, synthesized tones, lullabies, play songs, consonant and dissonant music, familiar and novel musical patterns. CR: Predominantly Western	Discussion of preferential listening, the head-turn preference procedure. Longer cumulative looking or listening for one of two stimuli is supposed to reveal differentiation of those stimuli	Reliance on looking measures alone results in incomplete or misleading information about music processing in infancy. The hypothesis that infants prefer consonance to dissonance seems to lack support	No single behavioral, physiological, or neural response measure can provide unambiguous information about music processing in infancy. Greater use of ecologically valid stimuli can increase the generality of the findings
4. Raschle et al. (43-50) Pediatric neuroimaging in early childhood and infancy: challenges and practical guidelines Cat. 9: Child development	To summarize and review pediatric imaging and analysis tools and to present guidelines and procedures that have been successfully implemented in neuroimaging research protocols	No particular musical material CR: ---	Various strategies and techniques as means of ensuring comfort and cooperation of young children during MRI and fMRI sessions. Fundamental aspects: Clear communication and child-centered, age-appropriate approaches	Practical challenges include participants' anxiety or motivation, movement restriction, putting an infant to sleep in the scanner area, masking and attenuation of scanner background noise, availability of child-appropriate equipment	Play therapy, behavioral training and simulation, the use of mock scanner areas, basic relaxation and a combination of these techniques have all been shown to improve the child's compliance and thus MRI data quality

SOCIAL / REAL WORLD METHODS (5-8)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
5. Uibel (51-55) Education through music - the model of the Musikkindergarten Berlin Cat. 7: Culture Cat. 10: Training	The method, the aim, and the experimental ground of the education is not only education *in*, *with* or *toward* music, but *through* music.	*Live music:* Regular participation of professional musicians from the Staatskapelle Berlin. One example: A project based on Saint-Saëns: The Carnival of the Animals. CR: Western	In the daytime living space of 60 children, music permeates all and acts as the central educational medium, which initiates and carries the processes of how children access the world	Education of auditory perception and differentiation, communication processes, dance and motor activity, mathematical proportions, physical principles of sound generation	Comparisons with children from other kindergarten suggest that children in the Musikkindergarten develop higher levels of social competency and communication skills
6. Majno (56-64) From the model of *El Sistema* to current applications: learning and integration through collective music education Cat. 7: Culture Cat. 10: Training	To present the goals and practice of the Venezuelan nationwide music education project “El Sistema”, and to survey and characterize a number of related projects in other countries	*Live music:* Music for symphony orchestras and choruses. CR: Cross-cultural: Western and Latin American	Music education free of charge. Regular training in nuclei that operate intensively four hours seven days a week. Children are from the start included in collective courses and ensembles	To offer social integration and music education as alternatives to juvenile crime, to counteract the risk of social unease, to stimulate emancipation and offer professional opportunities	It has been empirically proven that El Sistema and related projects compensate for social deprivation, lead to a realistic hope in a brighter future and a decrease in violent behavior among youth
7. Overy (65-68) Making music in a group: synchronization and shared experience Cat. 7: Culture Cat. 17: Sensorimotor	To encourage studies of the nature of everyday, non-expert forms of musical behavior, including social interaction, synchronization, body movements, and positive shared experiences	*Live music:* ”Real-world” musical experiences in formal and informal situations, such as pubs, nightclubs, birthday parties, weddings, rock concerts, church services, and sports events. CR: Western popular	Musical experiences in groups of untrained “non-musicians”, often involved in clapping, foot-tapping, singing and dancing, exuberant whole-body synchronized movement with opportunities for variation, creativity, leadership, imitation, error, and humor	The SAME (Shared Affective Motion Experience) model which proposes that auditory musical signals are heard not simply as abstract patterns of sound, but as a series of intentional, expressive motor acts, recruiting similar neural networks in both agent and listener	Group learning, shared musical experiences, synchronization, imitation and other socially interactive behaviors that are common to ”real-world” musical experiences may be valuable in music pedagogy and relevant for music intervention research
8. Osborne (69-76) Neuroscience and “real world” practice: music as a therapeutic resource for children in zones of conflict Cat. 8: Non-musicians Cat. 11: Disorder Cat. 12: Therapy	To exemplify and discuss how the results of research in the neurosciences of music can influence the practice of music therapeutic interventions for groups of traumatized children. Including references to Social Neuroscience and Communicative Musicality	*Live music:* 1) North Ugandan dances. 2) A melodic African chant and an old Arab song, ”Zeyn al Abidin”. 3) Songs composed by young people in traditional Thai scales. CR: Cross-cultural	Recording and reflecting on three interventions for the welfare of traumatized children: 1) Ayoma Camp, North Uganda, 2007. 2) Balata refugee camp, Palestinian West Bank, 2007. 3) Klong Loi in Southern Thailand, inhabited by displaced Burmese Thai, 2010	Neurophysiological symptoms of trauma, including increased heart rate, higher blood pressure, cardiac arrhytmias, irregularities in breathing, dysregulation of movement repertoires, dysregulations of systems for dealing with stress and relaxation	Music has proven to be an agent of change in many areas of psychosocial and social intervention among both postconflict and displaced populations. The co-occurrence of motor, emotional, and social responses to music is important

MECHANISMS OF RHYTHM AND METER LEARNING OVER THE LIFE SPAN (9-11)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
9. McAuley et al. (77-84) Tempo mediates the involvement of motor areas in beat perception Cat. 4: Rhythm Cat. 17: Sensorimotor	To investigate effects of tempo on beat-based processing by combining fMRI with a perceptual timing paradigm where participants made simple temporal judgments (speeding up or slowing down) about short rhythmic sequences	Beat sequences composed of 440-Hz sinus tones. Inter onset intervals: 600 msec, corresponding to 100 beats per minute (bpm) and 1500 msec, corresponding to a slower tempo, 40 bpm. CR: ---	fMRI scanning during listening to series of stimuli based on the implied beats of 100 bpm and 40 bpm. Simultaneous button-press indicates whether the sequence is experienced to speed up or to slow down.	Observation of task-related activity in a striato-thalamo-cortico network that includes the basal ganglia, thalamus, premotor and supplementary motor regions, and the insula. Comparison of ambiguous and unambiguous sequences	Rhythm perception recruits many motor-related areas even in the absence of overt movement. Rhythms presented at a slower tempo reduce involvement of a striato-thalamo-cortico network in beat-based processing.
10. Honing (85-91) Without it no music: beat induction as a fundamental musical trait Cat. 4: Rhythm Cat. 10: Training	To investigate whether beat and meter induction are innate or learned	One study: Six different sound patterns, variants of a rhythmic rock pattern with 8 grid points, using snare drum and bass, and hi-hat on every grid point. Four patterns were strictly metrical. Two deviant patterns omitted events on metrically salient positions. CR: Western popular	Reconsideration of studies with newborn and adults using Mismatch Negativity (MMN) tests to probe violations in a metrical expectation, such as a syncope or ”loud rest”	Whether hierarchical representations of rhythm are innate (active at day one), emergent (a structural property of the stimuli themselves), explicitly learned (a result of musical training), or implicitly learned (a result of mere exposure to music)	One study showed that the auditory system of a newborn is able to detect the periodicities induced by a varying rhythm. A related study with adults suggested that hierarchical representations for rhythms (meter induction) is formed automatically in the human auditory system
11. Hannon et al. (92-99) Effects of perceptual experience on children’s and adults’ perception of unfamiliar rhythms Cat. 4: Rhythm Cat. 7: Culture	To examine how passive exposure to music from a foreign culture influences perception of rhythm and meter at different ages	Test stimuli: Digitally generated isochronous and non-isochronous meters, both presented in four types: un-altered, structure-preserving, structure-disrupting, severely disrupted. *Recorded music* before 2nd test: Two weeks of at-home listening to a CD of non-isochronous Balkan dance music. CR: Cross-cultural: Western and Balkan	Five groups of participants, approx. 5, 7, 9, 11, and 18+ years. Tests before and after a two-week period of at-home exposure to recordings of complex-meter dance music from Macedonia, Bulgaria and Bosnia: After hearing a familiarization stimulus for 2 minutes, participants rated how similar four “test” renditions were to the original familiarization stimulus	Moderately complex nonisochronous meters with alternating long and short duration having 3:2 ratios do not pose a problem for listeners who are exposed to them from a young age. Participants over 11 years do not adapt as easily to unfamiliar rhythms	Passive at-home exposure to Balkan folk music gave rise to dramatic changes in the perception of non-isochro-nous and isochronous meter among 5-year olds, and to some extent among 7-year olds, but minimal effects among 11-year olds and adults

IMPACT OF MUSICAL EXPERIENCE ON CEREBRAL LANGUAGE PROCESSING (12-15)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
12. Kraus et al. (100-107) Cognitive factors shape brain networks for auditory skills: spotlight on auditory working memory Cat. 6: Language Cat. 8: Musicians Cat. 13: Attention	To examine biological underpinnings of musicians' auditory advantages and the mediating role of auditory working memory	Review of a number of studies that apply speech sounds as test stimuli, including full spoken sentences, lists of words and numbers, and single syllables such as "ba", "ga", and "da". CR: ---	in the review, processing approaches include correlation of the response to the stimulus, measuring noise-induced shifts in response timing, analyzing the frequency content of the response, and quantifying the timing/phase differences arising from frequency glides in consonant sounds	Accomplished musicians perform better in understanding speech in noise than their age- and hearing-matched peers. The auditory brainstem is a hub of sensory-cognitive interactions. The inferior colliculus is highly reciprocally connected with cortical areas	Descending projections from brain regions responsible for executive and limbic functions sharpen auditory processing. Auditory working memory is stronger in musicians and drives strengthened auditory processing as well as perceptual benefits for following conversations in noise
13. Francois et al. (108-115) Cognitive and methodological considerations on the effects of musical expertise on speech segmentation Cat. 6: Language Cat. 8: Musicians Cat. 10: Training	Testing the effect of musical expertise on a rather high cognitive function: speech segmentation	An artificial sung language (with speech and music combined in the same signal) compared to spoken language. CR: ---	Comparing speech segmentation in nonmusicians and professional musicians, coupling behavioral methods to EEG recordings	Understanding what aspects of music training (and its consequences on the brain) might contribute to beneficial effects for speech segmentation and to what extent	Results seem to show that musical training and expertise have effects on brain plasticity that may go beyond primary regions
14. Meyer et al. (116-123) Musical expertise induces neuroplasticity of the planum temporale Cat. 6: Language Cat. 8: Musicians	To investigate the relationship between musical expertise and structural, as well as functional, changes in the planum temporale (PT), which is an auditory-related association cortex, considered to be a spectro-temporal "computational hub"	Acoustic stimuli in fMRI studies: 1) Consonant-vowel (CV) syllables, tones, white noise, and vowels. 2) voiceless /ka/ and voiced /da/ German CV syllables, plus noise analogs of these syllables. 3) laughter, speech, and sounds. CR: ---	fMRI studies of responses in the auditory-related association cortex (PT) during the perception of rapidly changing information in speech and nonspeech sounds	Music and language share at least partially overlapping neural underpinnings. To what extent does musical expertise affect the functioning of the left and right plana temporalia?	Studies have demonstrated a dense relationship between musical experience, performance in phonetic processing, and leftward asymmetry of PT functional neuroanatomy. The left PT performs fine-grained auditory analysis
15. Patel (124-128) The OPERA hypothesis: assumptions and clarifications Cat. 6: Language Cat. 10: Training	Recent research suggests that musical training enhances the neural encoding of speech. The OPERA hypothesis proposes background for this effect	No references to specific musical stimuli. CR: ---	The OPERA hypothesis argues that musical training enhances the neural encoding of speech when five conditions are met: overlap, precision, emotion, repetition, and attention	Basic idea: That musical training demands greater precision in certain aspects of auditory processing than does ordinary speech perception	The paper presents two assumptions underlying the basic idea, as well as two clarifications, and suggests directions for future research

THE CULTURAL NEUROSCIENCE OF MUSIC (16-20)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
16. Trainor et al. (129-138) Becoming musically enculturated: effects of music classes for infants on brain and behavior Cat. 7: Culture Cat. 10: Learning Cat. 20: Musical expression	Comparison of two groups of 6-month-old Western infants assigned to 6 months of an active participatory music class or a class in which they experienced music passively while playing	*Recorded music:* 1) Thomas Attwood: Sonatina, original tonal version vs. altered atonal version. 2) Chopin Waltz op. 69 no. 1, expressive piano version vs. inexpressive synthesized version. CR: Western Western non-tonal	After participation, infants' preference for the different versions of the Atwood and Chopin pieces were measured in a head-turn preference procedure. (See also no. 3 above) EEG was measured while the infants listened to a repeating piano tone	Whether early exposure to a culture-based musical system and the cultural norms of musical expression leads to early preferences for those norms	Active music participation resulted in earlier enculturation to Western tonal pitch structure, larger and/or earlier brain responses to musical tones, and a more positive social trajectory
17. Vuust et al. (139-146) Practiced musical style shapes auditory skills Cat. 7: Culture Cat. 8: Musicians	To investigate differences in sound-related brain activity between different types of musicians by measuring the Mismatch negativity (MMN), a preattentive brain response, applying a novel, fast, multifeature MMN paradigm	Four-tone "Alberti-bass" patterns played with piano sample sounds, alternating between standard sequences and sequences including deviant features in pitch, timbre, location, intensity, slide and rhythm. CR: Western, W. popular	MMN response to six types of musical feature change was measured in musicians playing distinct styles of music (classical, jazz, and rock/pop) and in nonmusicians	To uncover fine-grained processing differences between musicians' and non-musicians' MMN responses	Jazz musicians had larger MMN amplitude than all other experimental groups across all sound features, indicating a greater overall sensitivity to auditory outliers. Findings indicate that the style of music played by musicians influence their perceptual skills
18. Tervaniemi et al. (147-151) Expertise in folk music alters the brain processing of Western harmony Cat. 2: Harmony Cat. 7: Culture Cat. 8: Musicians	To investigate Finnish folk musicians' neural response to chord violations embedded in musical cadences. In EEG recordings, an event-related potential (ERP) component called early right anterior negativity (ERAN) which is elicited by violations of chord cadences, was used as a probe	Seven-chord tonal cadences, digital piano chords. In 75 % of the cadences, a Neapolitan chord was placed at the 3rd, 5th or 7th position, producing an incongruous succession. Deviant chords with organ timbre were included in 8 % of cadences. CR: Western	Participants were 11 folk musicians who studied in a music academy or university, and 11 nonmusicians. They were instructed to press a button when they heard an organ timbre, thus the test was "semiattentive". EEG recordings were analyzed to find differences between groups and between chord positions	Working hypothesis: That the explicit training of folk musicians in non-Western musical systems would be reflected by reduced ERAN amplitude. The ERAN amplitude is a special index of Western tonal system	The working hypothesis was not supported.The Neapolitan chords at all three chord positions elicited a systema-tically larger ERAN amplitude in folk musicians as compared with nonmusicians. Interpretation: Folk musicians are sensitive to the intrinsic regularities of Western music due to their exposure to this music in daily life and, in some cases, explicit training in Western musical systems

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
19. Demorest & Osterhout (152-157) ERP responses to cross-cultural melodic expectancy violations Cat. 1: Melody Cat. 7: Culture Cat. 21: Improvisation	To explore the influence of cultural background on US-born listeners' ability to respond to expectancy violations in intact melodies from two cultural contexts	Participants listened to synthesized presentations of 30 European folk song excerpts and 30 excerpts from the melodic improvised introduction (alap) of different North Indian ragas. CR: Cross-cultural: Western traditional and Indian	Subjects: Ten college-age U.S. students. EEG: Event-related potentials (ERPs) corresponding to musical violations. All melodies were heard in their original form and in deviation form, changing a target note by one semitone.	1) Behavioral response: Subjects were asked to judge the congruence of the melody. 2) Averaged ERPs were calculated off-line from trials free of artifact. Of particular interest was the P600 effect	1) Subjects found the Indian melodies less congruous overall and were less sensitive to deviations in Indian melodies. 2) ERP data: Significant P600 responses to deviations in both cultural conditions, but less robust in the Indian context
20. Wong et al. (158-162) Effects of mono-and bicultural experiences on auditory perception Cat. 7: Culture	To discuss potential sources of cultural influence on auditory perception	Specially composed monophonic Western and Indian melodies with tempo, meter and key matched across cultures. Plus additional melodies with syntactic violations created to induce greater tension responses. CR: Cross-cultural: Western and Indian	fMRI study: Examining neural responses by monocultural Western listeners and bicultural Indian-Western listeners while they performed a judgment task, judging the tension evoked by Indian and Western melodies	Evaluating two hypotheses: 1) bottom-up: whether increased exposure to particular kinds of sound could shape auditory-neural responses. 2) top-down: whether cultural upbringing may have an impact on how we perceive the world	The studies discussed may only speak to one potential source of influence of culture on our auditory system, namely bottom-up, exposure-driven influences.

MEMORY AND LEARNING IN MUSIC PERFORMANCE (21-25)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
21. Bailey & Penhune (163-170) A sensitive period for musical training: contributions of age of onset and cognitive abilities Cat. 8;: Musicians Cat. 9: Child development Cat. 10: Training	To compare the performance of early-trained musicians (ET) and late-trained musicians (LT) on visual-motor and auditory-motor sychronization tasks	Six woodblock rhythms designed to cover a range of complexity: Two metrically simple, two metrically complex, and two non-metrical. CR: ---	Participants were 30 highly trained musicians, 15 ET and 15 LT, plus 20 non-musicians. *Rhythm task:* Alternating between listening and tapping along while each rhythm played twice. Performance variables measured: Percent correct, Asynchrony, Inter-tap interval deviation. Additional tests of cognition and memory	Whether plastic changes in the maturating brain depend on a "sensitive period" – a window of time during development when brain systems are more susceptible to the influence of experience or stimulation	Findings replicate previous findings and provide further evidence for a sensitive period for musical training. The ET musicians were better able to reproduce the rhythms than the LT musicians, even after controlling for years of formal training, playing experience, and current hours of practice

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
22. Pfordresher (171-178) Musical training and the role of auditory feedback during performance Cat. 10: Training Cat. 17: Sensorimotor	To consider how musical expertise influences the role of auditory feedback during music performance	*Task material, Live music:* Various studies, in which participants perform single-voice melodies on a keyboard. CR: Western	Different experimental paradigms appear to support different hypotheses of the learning process, "strict associationism", "motor schema formation", and "hierarchical shared representations"	To address the role of auditory feedback in music performance among both musically trained and untrained populations, by incorporating simplified melodies and forms of music notation that are easily learnable by nonmusicians	Results from various studies do not point towards a common consensus. Taken together, results suggest that musical training refines preexisting sensorimotor associations
23. Zimmerman & Lahav (179-184) The multisensory brain and its ability to learn music Cat. 10: Learning Cat. 16: Audiovisual	To highlight key multisensory regions within the brain and discuss their role in the context of music learning and rehabilitation	Review of numerous studies concerning multisensory brain regions. No musical material specified. CR: ---	One study: Two groups of non-musicians were trained to play piano music by ear; one group received audiovisual feedback, the other group heard, but could not see their hand on the keyboard.	Multisensory cortical brain regions associated with musical learning include the superior temporal sulcus, the interparietal sulcus, and the prefrontal cortex. Investigation of subcortical multisensory regions is suggested	Conclusion: Visual feedback improves pitch recognition. The multisensory nature of music making and listening concurrently stimulate multiple brain systems. This may be beneficial for neuro-logically impaired patients
24. Palmer et al. (185-191) Sensorimotor mechanisms in music performance: actions that go partially wrong Cat. 8: Musicians Cat. 14: Memory Cat. 17: Sensorimotor	To describe a study of the occasional unambiguous pitch errors that arise in a piano performance	*Task material, Live music:* Novel pieces, composed in 4/4 meter and consisting of 33 isochronous sixteenth notes in two parts. All pieces conformed to the conventions of Western polyphonic music. CR: Western	24 adult pianists performed four novel pieces twice, two at a medium tempo, two at a fast tempo. Errors in pitch accuracy were identified by computer comparison with the notated musical score	Several studies suggest that performance errors influence the force or timing of surrounding events. EEG studies have indicated some awareness that an error has been planned prior to its execution	Correct tones were produced with greater intensity than both pre-error tones and error tones. Thus, the locus of the error effect extended to the amount of force producing pre-error tones
25. Strübing et al. (192-199) Error monitoring is altered in musician's dystonia: evidence from ERP-based studies Cat. 8: Musicians Cat. 11: Deficit Cat. 17: Sensorimotor	To investigate Event-Related Potentials (ERPs) locked to pitch errors in professional pianists suffering from Musicians' dystonia (MD) and a control group of healthy professional pianists	*Task material, Live music:* Sequences consisting mainly of 16th notes, taken from the right-hand parts of J.S. Bach: The Well-Tempered Clavier Part 1, and one sequence from Haydn: Piano Sonata No. 52 in Eb major. CR: Western	Six MD patients and six healthy control subjects played six sequences ten times in a fast tempo. Continuous EEG signals were recorded and analyzed, focusing on two components, the error-related positivity and the pre-error-related negativity	In the manifestation of musicians' dystonia, impaired sensorimotor integration and decreased inhibition of the sensorimotor pathways play important roles. Deficient inhibition also leads to hypersensitive basal ganglia pathways	The between-group analysis depicted significantly larger error-related brain responses before and following errors in MD patients compared with healthy pianists. MD seems to be related to error-monitoring processes associated with the basal ganglia

MIND AND BRAIN IN MUSICAL IMAGERY (26-29)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
26. Halpern (200-205) Dynamic aspects of musical imagery Cat. 13: Anticipation Cat. 14: Memory, imagery	To present two recently published studies which concentrate on the dynamic, or time-sensitive aspects of musical imagery	*Recorded music,* very familiar to the participants: The first minute of Beethoven: Fifth Symphony; Tchaikovsky: "Waltz of the Flowers" from Nutcracker Suite; Mozart: Allegro from Eine kleine Nachtmusik. CR: Western	Study 1: Tracking valence and arousal of the music on a computer screen, first while listening to the music, then while imagining the same music Study 2, fMRI: Brain activation during anticipation of sound sequences	1) How well people could extract emotional judgments of music in real time as they listened to, and then imagined, a familiar piece of music. 2) The neural correlates of anticipating an upcoming tune, after hearing a cue tune	Study 1: Emotional response profiles to heard and imagined music were very similar. Study 2: In the anticipatory response, brain areas associated with motor sequence learning were active, e.g. the supplementary motor areas and globus pallidus
27. Keller (206-213) Mental imagery in music performance: underlying mechanisms and potential benefits Cat. 13: Anticipation Cat. 14: Memory Cat. 17: Sensorimotor	To examine the role of mental imagery in music performance, including the multi-modal process of generating the mental experience of musical sounds and action simulation	Review of various studies, no musical material specified. Music mentioned in anecdotal information: Schumann: Humoreske op. 20. Cesar Franck: Symphonic Variations. CR: Western	Reviews: Cognitive/motor mechanisms underlying imagery during performance, benefits of anticipatory auditory imagery, and neural correlates of imagery-based temporal prediction	It is possible to decode patterns of brain activity associated with the time course of imagining specific musical pieces and rhythmic structures	The deliberate use of anticipatory auditory, motor and visual imagery during performance may benefit the control of timing, intensity, articulation, and intonation
28. Janata (214-221) Acuity of mental representations of pitch Cat. 1: Pitch Cat. 13: Expectation Cat. 14: Memory	To investigate and discuss auditory images (mental representations) of one or more pitches. It appears useful to think of auditory images in terms of a perception-action cycle	*Task material:* 1) Pairs of synthesized complex harmonic tones. 2) Ascending scales followed by a probe note. Notes synthesized in Matlab. CR: Western	Behavioral tasks: 1) Two-note discrimination task, 2) Cued-attention task, 3) imagery task. EEG: Mismatch negativity (MMN) studies, focusing on secondary auditory cortex processing	Our minds maintain an "auditory" world that exists both independently and in interaction with the auditory world around us. Multiple memory systems contribute to the formation of accurate mental images for pitch	A view of auditory mental images is espoused in which unified mental image representations are distributed across multiple brain areas
29. Zatorre (222-228) Beyond auditory cortex: working with musical thoughts Cat. 13: Recognition	To describe functional magnetic resonance (fMRI) studies requiring manipulation of musical information	One study: Opening notes of familiar tunes in synthesized piano timbre, e.g. "White Christmas", theme from "Pink Panther", "Greensleeves", and notes in reversed order CR: Western traditional, W. popular	fMRI studies investigating musical tasks: 1) recognition of reversed melodic patterns, 2) recognition of transposed melodic patterns	Activation within the interparietal sulcus (IPS), a complex cortical region known to receive inputs from many modalities and to be implicated in a wide range of tasks	Findings suggest that the dorsal pathway of auditory processing, going to parietal, premotor, and dorsolateral frontal cortex, is involved in the manipulation and trans-formation of auditory information

MUSIC AS A MEANS TO INDUCE BRAIN PLASTICITY AND MALPLASTICITY IN HEALTH AND DISEASE (30-34)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
30. Schulze & Koelsch (229-236) Working memory for speech and music Cat. 8: Musicians Cat. 14: Memory	To review behavioral and neuroimaging findings on similarities and differences between verbal and tonal working memory (WM), and the influence of musical training	Review of numerous studies. No particular musical material specified. CR: ---	The review is theoretically embedded in the WM model in which verbal information is processed by a phonological loop, including a passive storage component and an active articulatory rehearsal mechanism	To discuss preliminary findings that imply, if confirmed, the existence of both a tonal loop and a phonological loop in musicians	Research on WM for pitch or "The tonal loop" does not yet provide a consistent picture. Preliminary findings in musicians suggest differences in neural activation during verbal WM or tonal WM
31. Zipse et al. (237-245) When right is all that is left: plasticity of right-hemisphere tracts in a young aphasic patient. Cat. 5: Song Cat. 6: Language Cat. 11: Disorder Cat. 12: Recovery Cat. 17: Sensorimotor	To determine whether functional and structural brain changes after Melodic Intonation Therapy (MIT) could be observed in a 12-year-old girl with extensive left-hemisphere lesion	*Task material:* Melodic Intonation Therapy (MIT) for nonfluent aphasia: Sentences are intoned (sung) on two pitches, while the clinician taps the patient's left hand once per syllable CR: ---	Treatment: Five MIT sessions per week for 16 weeks. fMRI was used to assess cortical activity during the repetition of spoken phrases. Fiber tracts associated with speech processing were measured using diffusion Tensor Imaging (DTI)	To determine whether improvements seen with MIT are associated with increased right-hemisphere activity	Improved performance on speech and language tasks after treatment was accompanied by fMRI changes in the right frontal lobe, and increased volume of white matter pathways in the right hemisphere
32. Jäncke (246-252) The dynamic audio-motor system in pianists Cat. 10: Training Cat. 17: Sensorimotor	To examine whether the strength of the functional relationship between the Auditory Cortex (AC) and the Premotor Cortex (PMC) varies during piano playing	*Task material, Live music:* Pianists play *Sonata facile* by Mozart on an electrical piano, with and without auditory feedback. CR: Western	EEG was measured during rest and during piano playing. The processed data were subjected to standardized low-resolution electrical tomography (sLORETA) to estimate the intracerebral sources of brain activity	Hypothesis: The functional relationship between the intracerebral electrical activations in the AC and the PMC should be rhythmically decreased and increased	Main finding of this preliminary study: There is a causal relationship between the AC and the PMC, which dynamically varies across piano playing and which even varies during rest in pianists
33. Pantev et al. (253-258) Tinnitus: the dark side of the auditory cortex plasticity Cat. 11: Deficit Cat. 12: Recovery	To illuminate an innovative tinnitus treatment strategy based on regular listening to individual and enjoyable, specially filtered music	*Recorded music:* Self-chosen, enjoyable music that is modified ("notched") to contain no energy in the frequency range surrounding the individual tinnitus frequency. CR: Western, Western popular	39 tinnitus patients were assigned to a target group hearing "notched" music, a placebo group hearing music with placebo modification, and a control group hearing unmodified music. Daily listening during one year.	Attracting lateral inhibition to the brain area generating tinnitus	We have developed and evaluated a customized music training strategy that appears capable of both reducing cortical tinnitus-related neuronal activity and alleviating subjective tinnitus perception

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
34. Altenmüller et al. (259-265) Musician's cramp as manifestation of maladaptive brain plasticity: arguments from instrumental differences Cat. 11: Deficit Cat. 17: Sensorimotor	To present data from 591 musicians from an outpatient clinic demonstrating an influence of fine-motor requirements on the manifestation of musicians' dystonia (MD), also known as musicians' cramp or focal dystonia	No music specified. The study includes patients who are professional musicians playing keyboard, string instruments, plucked instruments, woodwind, brass and percussion. CR: ---	Statistical analysis of 591 patient files diagnosed with focal dystonia. Brass instruments, plucked instruments, and woodwind players show the highest risk for focal dystonia.	A combination of a genetic predisposition and behavioral triggering factors constitute the leading factors for the manifestation of the disorder. Occurrence of MD seems to be heavily influenced by environmental and behavioral factors	The maladaptive brain plasticity in MD is strongly influenced by specific triggering factors, such as high requirements on manual skills, precision of movements, and extra instrumental burdens linked to skilled use of the dominant hand

THE ROLE OF MUSIC IN STROKE REHABILITATION: NEURAL MECHANISMS AND THERAPEUTIC TECHNIQUES (35-39)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
35. Särkämo & Soto (266-281) Music listening after stroke: beneficial effects and potential neural mechanisms Cat. 11: Deficit Cat. 12: Recovery	To present findings about the short- and long-term effects of music listening on the recovery of cognitive function in stroke patients and the underlying neural mechanisms of these music effects	*Recorded music:* Study 1: Pleasant music selected by the patient, and unpreferred music selected by the experimenter. Study 2: One group listens to CDs of patient's favorite music, encompassing popular music with lyrics, jazz, folk, and classical. Another group listens to audio books. CR: Western and W. popular	Study 1: Three patients suffering from visual neglect after stroke perform a computerized visual task as they listen to either preferred or unpreferred music or in a silence condition. Study 2, Randomized controlled: A music group and an audio book group listen daily to the material for two months. A control group is not given listening material	Study 1: Facilitating visual awareness in patients with visual neglect by listening to pleasant music. Study 2: Effect of daily music listening on long-term stroke recovery. Cognitive tests and questionnaires measure memory, language skills, perception, cognition and attention, mood and quality of life. MEG and MRI measure neuroplastic changes	Study 1: Results suggest that positive affect, through music, can increase attention resources available for visual processing. Study 2: Daily music listening can improve auditory and verbal memory, focused attention, and mood as well as induce structural gray matter changes in the early poststroke stage
36. Rodriguez-Fornells et al. (282-293) The involvement of audio-motor coupling in the music-supported therapy applied to stroke patients Cat. 11: Deficit Cat. 12: Recovery	To present and discuss studies on the involvement of auditory-motor coupling in the Music-supported therapy (MST) in chronic stroke patients	MST uses musical instruments, an electronic piano and an electronic drum set emitting piano tones. CR: Western	*Task:* The patient uses musical instruments to retrain fine and gross movements of the paretic hand and arm. Review of fMRI studies of the functional connectivity between the regions involved in the auditory-motor circuit	Using MST for exploiting residual learning abilities in stroke patients through indirect, intact brain pathways engaged by music performance. Understanding the dynamics involved in the neural circuit underlying audio-motor coupling	This preliminary report suggests that MST could be effective in chronic stroke and acute patients and that it has a direct impact in the functional connectivity of the audio-motor networks that support musical perception and learning

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
37. Fujioka et al. (294-304) Changes in neuromagnetic beta-band oscillation after music-supported stroke rehabilitation Cat. 11: Deficit Cat. 12: Recovery	To examine functional coordination between auditory and sensorimotor systems in chronic stroke patients receiving Music-supported therapy (MST), indexed by beta-band oscillations (15-30 Hz)	Similar to no. 36 above: Retraining the affected upper limb, using an electronic piano and an electronic drum set emitting piano tones. CR: Western	Three patients received MST (see no. 36) for fifteen 30-minute sessions. Tasks for MEG recording: listening to a metronome beat, and tapping in synchrony with the index finger, affected and less-affected side	Hypothesis: That motor rehabilitation training incorporating music playing will stimulate and enhance auditory-motor interaction in stroke patients.	In all three patients, the intervention had a significant effect on the amplitude of the beta power change in bilateral auditory and sensorimotor cortices in the auditory listening condition. However, improvement in motor skills was only subtle
38. van Wijck et al. (305-311) Making music after stroke: using musical activities to enhance arm function Cat. 11: Deficit Cat. 12: Recovery	To describe key principles and development of a novel intervention that integrates individuals' preferred music with game technology in arm rehabilitation	*Recorded music:* Participant-selected music is synchronized with computer game graphic. CR: Western popular	Description of a prototype intervention based on "off-the-shelf" Nintendo Wii game technology. The "tap tempo game" uses rhythmic auditory cueing for repetitive arm training.	To improve self-management strategies for people with stroke, who continue to experience impaired arm function	This intervention is anticipated to open up novel opportunities to tailor a technology for use in the home environment as a strategy for self-managed arm rehabilitation
39. Tomaino (312-317) Effective music therapy techniques in the treatment of nonfluent aphasia Cat. 11: Deficit Cat. 12: Therapy	To give an overview of various techniques used in music therapy and summarize findings of the outcomes and benefits of these techniques for aphasic patients	Familiar songs, clapping or tapping speech rhythm, vocal intonation of daily speech phrases. CR: Western	*Training tasks:* Singing familiar songs, musically assisted speech, dynamically cued singing, rhythmic speech cueing, oral motor exercises, vocal intonation, finger tapping	Various benefits of singing have been identified: strengthened breathing and vocal ability, improved articulation and prosody of speech, and increased communicative behaviors	Music therapy and music-based speech protocols provide useful tools for the rehabilitation of patients with non-fluent aphasia

MUSIC: A UNIQUE WINDOW INTO THE WORLD OF AUTISM (40-42)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
40. Molnar-Szakacs & Heaton (318-324) Music: a unique window into the world of autism Cat. 1: Pitch Cat. 11: Disorder	To investigate the nature of emotion processing difficulties in autism spectrum disorders (ASD), in particular the dissociation between emotion recognition abilities in musical and social domains	*Recorded music:* Excerpts representing happy, sad, peaceful, and fearful emotions. Affective vocal gestures, and numbers spoken with affective intonation. Environmental noises. CR: Western and W. popular	Review of various studies, including observational studies aimed at recognizing emotions in musical excerpts, and fMRI studies of cortical and subcortical regions activated during music listening	Behavioral studies suggest that difficulties in recognizing emotions in voices and faces do not generalize to the domain of music	Children with ASD show significant increase in their responses to music compared with speech and environmental noise. fMRI data suggest that hypoactivity in the anterior insula plays a seminal role in the emotion-perception related deficits seen in autism
41. Ouimet et al. (325-331) Auditory-musical processing in autism spectrum disorders: a review of behavioral and brain imaging studies Cat. 11: Disorder	A critical evaluation of behavioral and brain imaging studies of auditory-musical processing with respect to current theories in autism spectrum disorder (ASD)	One study: Listening to nine-tone melodies with synthesized tones using 5 harmonics. CR: Western	Overview of perceptual and neurobiological theories in ASD: *The weak central coherence theory, The enhanced perceptual functioning model, The under-connectivity hypothesis, and The intense world theory*	Auditory-musical processing in terms of global versus local processing and simple versus complex sound processing	Preliminary findings favor *The enhanced perceptual functioning model of ASD* (which predicts enhanced local processing in ASD but intact global processing) over *The weak central coherence theory* (which predicts diminished global processing) Additional brain imaging studies are required
42. Wan et al. (332-337) Atypical hemispheric asymmetry in the arcuate fasciculus of completely nonverbal children with autism Cat. 11: Disorder Cat. 17: Sensorimotor	Comparing the structure of a language-related white matter tract (the arcuate fasciculus, AF) in five completely nonverbal children with autism spectrum disorders (ASD) to that of typically developing children.	No musical stimuli CR: ---	Comparison of five nonverbal ASD children with five typically developing (TD) children, mean age in both groups 7 years. Using MRI scanning and diffusion tensor imaging, fiber tracking identified the arcuate fasciculus (AF) on both the left and right hemispheres of all 10 children	Recently, our laboratory has developed a novel intonation-based intervention, auditory-motor mapping training (AMMT), which aims to facilitate speech output and vocal production in nonverbal children with ASD	TD children showed greater AF tract volume in the left hemisphere compared to the right hemisphere, whereas four of the five nonverbal ASD children showed the reversed pattern of asymmetry (larger right than left AF volumes). This abnormal structure of the AF may underlie some of the severe language defects in autism

LEARNING AND MEMORY IN MUSICAL DISORDERS (43-46)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
43. Dalla Bella et al. (338-344) Memory disorders and vocal performance Cat. 14: Memory Cat. 17: Sensorimotor	Investigating the role of memory for poor-pitch singing in individuals suffering from congenital amusia and unimpaired occasional singers	Melodies: ”Gens du Pays” (Francophone Canada), ”Brother John”, ”Jingle Bells”, ”Sto lat” (Poland) CR: Western, W. popular	11 amusics were compared with 11 matched controls. *Tasks:* Study 1: Singing a familiar melody from memory a) with lyrics, b) on a syllable, ”la” or ”ta”. Study 2: Singing a familiar melody a) from memory, b) imitating an accurate performance of the melody, c) in unison with the accurate performance	Disturbed perception and deficient sensorimotor mapping have been underlined as important causes of poor singing. Yet, memory has been paid relatively little attention	The findings point to memory as a relevant source of impairment in poor singing, and to imitation as a useful aid for poor singers
44. Anderson et al. (345-353) Is there potential for learning in amusia? A study of the effect of singing intervention in congenital amusia Cat. 10: Learning Cat. 11: Deficit	To determine which aspects of congenital amusia may be subject to change	Own choice songs, ”Happy Birthday”, warm-ups such as lip-flutters and glides, simple well-known melodies, free composition. CR: Western	Five amusic female adults were compared with five female matched controls. *Assessment tasks:* 1) Matching two pitches on a computer, 2) singing with and without accompaniment, 3) singing back recorded stimuli. *Intervention:* Seven weekly group-singing workshops, designed to enhance singing technique, vocal health and efficiency, musical understanding, pitch perception and production	Understanding which aspects of congenital amusia are subject to change constrains theorizing about the nature of the disorder, and can facilitate possible future remediation programs.	Song production improved for all participants. Different individuals may benefit from different aspects of a broad-brush intervention approach. The research project has suggested productive compensatory tactics for the singing teacher working with poor-pitch singers, and fruitful lines for further research.

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
45. Loui & Schlaug (354-360) Impaired learning of event frequencies in tone deafness Cat. 10: Learning Cat. 11: Disorder	To investigate whether difficulties in pitch and melody discrimination among tone-deaf (TD) persons could be related to learning difficulties	Eight-tone melodies in a new musical system, the Bohlen-Pierce scale. This scale is based on the 3:1 frequency ratio (a ”tritave” instead of an octave). Within the tritave there are 13 logarithmically even divisions. Electronic sound using Max. CR: Western non-tonal	A three-phase experiment, comparing eight TD individuals with eight non-TD individuals. 1) Pre-test: Listening to 13 melodies, each followed by a ”probe” tone. *Task:* To rate how well the probe tone fits the preceding melody. 2) Exposure: Listening to 400 melodies in the new musical system. 3) Post-test: Same as the pre-test.	Whether half an hour of exposure to the frequency structures of a new, unfamiliar musical system would produce sensitivity to the frequency structures of the new system in TD individuals and the control group	The control group acquired sensitivity to the unfamiliar frequency structures after exposure, whereas TD individuals showed no such improvement. Results suggest that tone deafness is characterized by an impaired ability to acquire frequency information from pitched materials in the sound environment
46. Peretz et al. (361-367) Statistical learning of speech, not music, in congenital amusia Cat. 10: Learning Cat. 11: Disorder	To test whether amusics might be able to acquire basic musical abilities by way of statistical learning if given appropriate exposure	Continuous streams of syllables or tones organized according to simple statistical regularities, in particular: 1) Synthesized speech syllables making up three-syllable nonsense words: babupu, bupada, dutaba, patubi, pidabu, tutibu; 2) Diatonic tones in piano timbre making up three-tone motifs. CR: Western	11 adults with congenital amusia and 13 matched controls were tested. In a familiarization phase, they were exposed to a continuous stream of syllables or tones for at least 21 min. Their subsequent task was to try to identify words or motifs heard in the familiarized material.	Whether inappropriate musical exposure accounts for the musical disorder in amusics	Amusics can after appropriate exposure learn novel words as easily as controls, whereas they systematically fail on musical materials. The results suggest that statistical learning is mediated by two systems specialized for processing syllables and tones

ONLINE ONLY (47)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Prcedure	Main focus of interest	Conclusion
47. Large & Almonte Neurodynamics, tonality, and the auditory brainstem response Cat. 1: Scales *Online only:* Ann. N.Y. Acad. Sci. 1252 (2012) E1–E7 doi: 10.1111/j.1749-6632.2012.06594.x	To propose a new theory of musical tonality which treats the central auditory pathway as a complex nonlinear dynamical system	Input to the neural network model was the waveform of an acoustic stimulus, the simultaneous musical interval G-E, recorded on electric piano CR: Western	Construction of an artificial neural network in which one network simulates non-linear cochlear filtering, and the second and third networks simulate mode-locked responses in the cochlear nucleus (CN) and inferior colliculus (IC)	A recent dynamic theory of musical tonality predicts that networks of auditory neurons resonate nonlinearly to musical stimuli. Hypothesis: Time-locked neural activity is carried forward by active oscillatory circuits in the central auditory system, leading to nonlinear spectrotemporal receptive fields (STRF) and auditory brainstem responses (ABR)	The current approach provides an alternative model of nonlinear signal processing that makes predictions about neural population responses that qualitatively match human auditory brainstem responses. This suggests that fundamental principles of auditory neurodynamics might underlie the perception of tonal relationships

The Neurosciences and Music V: Cognitive Stimulation and Rehabilitation. Conference 29 May – 1 June, 2014 in Dijon, France.

A survey of the 34 papers in the conference proceedings:
***Annals of the New York Academy of Sciences*, Volume 1337 (March 2015)**
edited by Emmanuel Bigand, Barbara Tillmann, Isabelle Peretz, Robert J. Zatorre, Luisa Lopez, and Maria Majno.

Contents:

The survey presents, in brief and schematic form, for each paper:

Abbreviated title as indicated in the conference proceedings, with page numbers.
Categories of investigation
Aim of the study
Musical material and Cultural references
Technology and Procedure
Main focus of interest
Conclusion

Keynote address

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. Bherer (1-6) Cognitive plasticity in older adults: effects of cognitive training and physical exercise Cat. 10: Training Cat. 13: Cognition, attention	To review studies of computerized cognitive training and physical exercise to improve cognition and physical functioning in healthy older adults	Physical training programs including dance interventions and aerobic exercise. CR: Western popular	Review of numerous studies	The brain seems to maintain an impressive level of plasticity throughout life, even at a very advanced age and despite reduced physical condition	Cognitive stimulation, achieved through computer software or a physical activity program, seems to momentarily enhance cognition and may lead to benefits in real-life situations

Musical rhythm and language development: basic research and implications for rhythm-based interventions

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
2. Kovelman et al. **(**7-15) Multimodal imaging of temporal processing in typical and atypical language development Cat. 4: Rhythm Cat. 6: Language Cat. 9: Development	To report three studies which address whether the brain's sensitivity to slow rhythmic syllable-length information and statistical information relate to language and reading abilities in typically and atypically developing children	Study 1) Listening passively to acoustic beats occurring at low frequencies. Study 2) Comparison of two different 800 msec pure tones. Study 3) Listening to words in a foreign language CR: -	1) Functional near-infrared spectroscopy (fNIRS) study of children's perception of rhythmic beats. 2) fMRI study of children's amplitude rise-time perception. 3) Magneto-encephalography (MEG) study to investigate statistical learning of language in children	Two types of linguistic rhythms: a) temporal properties of rhythmic syllable and phoneme alternations. b) vowel-to consonant duration ratis that aid language segmentation	The overall findings suggest that the efficiency with which left temporal regions process slow rhythmic information may be important for gains in language and reading proficiency
3. Gordon et al. (16-25) Perspectives on the rhythm-grammar link and its implications for typical and atypical language development Cat. 4: Timing, rhythm Cat. 6: Language Cat. 9: Development	To review evidence for shared cognitive mechanisms and neural resources for rhythm and grammar	Tests of rhythm perception skills: Beat-Based Advantage (BBA) and Primary Measures of Musical Aptitude (PMMA) CR: Western	25 typically developing (TD) 6-year old children. Tests of rhythm perception skills were compared with tests of expressive grammar, measured with the Structured Photographic Expressive Language Test (SPELT-3)	Whether musical rhythm discrimination can explain individual differences in grammar skills in children	Variance in musical rhythm perception in 6-year old typically developing children predicts global grammatical performance, and is associated with mastery of complex sentence structure

Temporal expectations in a developmental perspective

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
4. Morillon and Schroeder (26-31) Neuronal oscillations as a mechanistic substrate of auditory temporal prediction Cat. 4: Rhythm, timing Cat. 6: Language Cat. 13: Prediction	To argue that oscillatory temporal predictions can selectively amplify neuronal sensitivity, and that the motor system is involved in the generation of such temporal predictions	Attention-engaging task: Sequences of eight pure tones were delivered in phase with a reference beat, and in antiphase with irrelevant distractor tones. CR: -	Review of evidence for the idea that ongoing oscillations provide a neurophysiological substrate for temporal prediction. Moreover, a report of a novel behavioral experiment: pressing in rhythm with a reference beat, or keeping the rhythm covertly, while performing an attention-engaging task	It is suggested that speech perception arises from the dynamic sampling of acoustic information at multiple timescales simultaneously. Auditory delta (1-4 Hz), theta (4-8 Hz), and low-gamma (25-45 Hz) frequencies may play a prominent role in speech parsing	Findings show that producing a rhythmic movement engages a top-down modulation that sharpens the temporal selection of auditory information. Results suggest that motor-driven temporal predictions optimize perception
5. Schön and Tillmann (32-39) Short- and long-term rhythmic interventions: perspectives for language rehabilitation Cat. 4: Rhythm, timing Cat. 6: Language Cat. 12: Rehabilitation Cat. 13: Attention	To see whether music can entrain attentional processes and affect speech and language perception and production and possibly explain the potential underlying mechanisms	Material for three experimental designs: 1) Rhythmical isochronous sequences of drum sounds. 2) Regular and irregular rhythmic structures played by two percussion instruments. 3) Two years of music training based on a combination of Kodaly and Orff approaches CR: Western	Experiments combining music and speech: 1) Studying whether rhythmic cueing may benefit speech perception. 2) Comparing a regular and an irregular prime on syntax processing. 3) Assessing the links between musical rhythm and language processing in a long-term training of rhythmic skills	Hypothesis: Temporal attention can be influenced by musical rhythm and benefit subsequent language processing, including syntax processing and speech production	Data support the hypothesis of a causal role of rhythm-based processing for language processing and acquisition

The beat: a structured environment for movement, communication, and socialization

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
6. Schaefer and Overy (40-44) Motor responses to a steady beat Cat. 4: Rhythm, beat Cat. 12: Rehabilitation Cat. 17: Entrainment, synchronization	To discuss the well established knowledge that music containing an isochronous pulse elicits motor responses at the levels of both brain and behavior	Metronome beats, music with a steady beat, and music with a groove, created by the addition of syncopated rhythms to a steady beat pattern CR: Western popular	Review of various studies: Synchronizing dance steps or simple wrist movements to music. Adjusting the synchronization of finger taps to a tempo-varying metronome. Using rhythms with a steady beat in movement rehabilitation	The nature of motor responses that can arise from the perception of a steady auditory pulse has not received adequate research attention	The beat in musical rhythm is not perceived in the same way by all populations; nor is the level of attention that is necessary for accurate beat tracking always present, or the motor control that is necessary to adjust movement to sound
7. Trainor and Cirelli (45-52) Rhythm and interpersonal synchrony in early social development Cat. 4: Rhythm, beat Cat. 9: Development Cat. 17: Synchronization	To review evidence for a link between synchronous movement and prosocial behavior in adults and infants	1) Bouncing infants to ambiguous sound patterns: bouncing on every second beat or on every third beat. 2) Bouncing infants in synchrony or asynchrony with The Beatles: *Twist and Shout.* CR: Western, Western pop	1) Testing listening preferences of the bounced infants. 2) Testing whether infants bounced in synchrony or asynchrony with an adult would hand back objects ”accidentally” dropped by the adult	Research indicates that synchronous movements between adults increases group cohesion and social cooperation. Joint attention is an important ingredient in early social cognition	1) Infants preferred to listen to the rhythm pattern with accents that matched how they had been bounced. 2) synchronous movement to music has prosocial effects, increasing altruistic behaviors in young infants
8. Leow et al. (53-61) Familiarity with music increases walking speed in rhythmic auditory cueing Cat. 4: Groove. Cat. 10: Training Cat. 17: Synchronization Cat. 19: Emotion	To assess how familiar and unfamiliar high- and low-groove music affected synchronization and gait in healthy individuals	26 music clips of familiar and unfamiliar high-groove and low-groove music CR: Western popular	11 healthy volunteers. Tests: 1) Walking in synchrony. 2) Rating pleasantness, enjoyment, arousal and familiarity of songs	To optimize future interventions by means of rhythmic auditory stimulation (RAS) for gait rehabilitation	In RAS, music high in familiarity and high in groove elicits more accurate tempo matching and faster strides. High-groove music elicits faster strides than low-groove music
9. Kotz and Gunter (62-68) Can rhythmic auditory cueing remediate language-related deficits in Parkinson’s disease? Cat. 4: Rhythm, beat Cat. 6: Language Cat. 11: Disorder Cat. 12: Rehabilitation	To explore whether language-processing deficits in idiopathic Parkinson’s disease (IPD) can be remediated via rhythmic auditory cueing	Three minutes of march music (4/4) and three minutes of waltz music (3/4), Thomas Koschat: *Schneewalzer.* CR: Western	Before listening to naturally spoken sentences that were correct or incorrect, an individual with IPD heard a march which metrically aligned with the speech accent structure, or a waltz that did not align. Continuous EEG signals were recorded.	A marching rhythm may lead to a stronger engagement of the Cerebello-thalamo-cortical (CTC) circuit that compensates dysfunctional timing by the Basal ganglia-thalamo-cortical (BGTC) circuit (also denominated the striato-cortical circuit)	Only the cueing with a march led to improved computation of syntactic and semantic information

Moving on the beat of music: bridging training, rehabilitation strategies, and technology

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
10. Scholz et al. (69-76) Moving with music for stroke rehabilitation: a sonification feasibility study Cat. 10: Training Cat. 11: Deficit Cat. 12: Therapy, Rehabilitation Cat. 17: Sensorimotor	To present a novel sonification therapy especially designed to retrain gross-motor functions. While stroke patients train arm movements with their affected arm, the arm movements are transferred into sound	Sonification training: manipulating musical parameters by moving the affected arm in a 3D space. Parameters: 1) Pitch, a C major scale. 2) Brightness of sound, from clarinet to saxophone to bowed instrument. 3) volume level. CR: Western	Music group (MG): Two stroke patients received standard care plus 9 days of musical sonification training. Control group (CG): Two stroke patients received exactly the same care and training, but without sound. Pre-and post-test battery of motor functions	The possible effect of sound playback in training of upper-extremity functions	The two music group patients improved in nearly all motor functions after training. The two control group patients benefited less from the training. Sonification may be a promising therapy. However, results have to be verified in a large group of patients
11. Dalla Bella et al. (77-85) Effects of musically cued gait training in Parkinson's disease: beyond a motor benefit Cat. 4: Rhythm, beat Cat. 10: Training Cat. 11: Disorder Cat. 17: Sensorimotor	To report behavioral data showing beneficial effects of musically cued gait training (MCGT) on gait performance, perceptual timing, and sensorimotor timing abilities in patients with idiopathic Parkinson's disease (PD)	Gait training: 1) walking along with a familiar German folk song without lyrics. 2) The Battery for the Assessment of Auditory Sensorimotor and Timing Abilities (BAASTA), includes tasks with musical stimuli and tapping tasks CR: Western, W. traditional	Pre- and post-tests of 15 patients with moderate PD submitted to MCGT compared to 20 healthy adults.	The functions of the basal ganglia-thalamocortical network (BGTC) and the cerebellar-thalamocortical network (CTC). Hypothesis: Compensation involves the CTC if the functionality of the BGTC breaks down in PD	1) Results showed benefits of the MCGT on spatiotemporal gait parameters. However, some patients did not respond to training. 2) Benefits of auditory cueing training appear to extend to perceptual and motor timing
12. Moens and Leman (86-93) Alignment strategies for the entrainment of music and movement rhythms Cat. 4: Tempo, beat Cat. 17: Entrainment	To present and test D-Jogger, a music player that functions as a mediator between music and locomotion rhythms	Selections of pop music displaying salient beat and groove CR: Western popular	Tests of four different strategies that align the relative phase of the footfall and the musical beat	D-Jogger is a technology that can increase or decrease the tempo of a song to fall in synchrony with a person's footfall	Results suggest that D-Jogger can serve as an assistive technology to motivate people to exercise physically, and for physical rehabilitation
13. Bardy et al. (94-100) Sound-induced stabilization of breathing and moving Cat. 4: Rhythm, beat Cat. 17: Synchronization Cat. 18: Bodily impact	To test the effect of an external auditory stimulus on locomotor-respiratory coupling (LRC)	Task: Cycling or breathing in synchrony with a metronome CR: -	16 healthy participants were instructed to synchronize their respiration or pedaling rate with the external auditory stimulus of a metronome. Measurements of LRC with and without auditory stimulus	In humans and other animals, the locomotor and the respiratory system are naturally coupled together	Simple periodic auditory stimulation is an efficient way to stabilize LRC. Similar effects of music are suggested

Individual differences in movement coordination: effects of training, aptitude, and neurological disorders

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
14. van der Steen et al. (101-110). Modeling effects of cerebellar and basal ganglia lesions on adaptation and anticipation during sensorimotor synchronization Cat. 4: Tempo Cat. 11: Deficit Cat. 17: Synchronization	To investigate the role of subcortical brain structures in temporal adaptation and anticipation during sensorimotor synchronization with auditory sequences	Auditory pacing sequences with and without tempo changes. Stimulus sounds were woodblock samples. No cultural references. CR: -	15 patients with basal ganglia lesions, 11 with cerebellum lesions, and a control group. Two sensorimotor synchronization tasks involved the use of a drumstick to tap in time with auditory pacing sequences	A computational model of adaptation and anticipation (ADAM) was employed to uncover potential sources of individual differences in participants' behavior. Division of labor between basal ganglia and cerebellum	Lesions of the cerebellum and basal ganglia impair precision in sensorimotor synchroni-zation by increasing the variability of timekeeper and motor processes as well as by reducing the ability to generate temporal predictions
15. Hove and Keller (111-117) Impaired movement timing in neurological disorders: rehabilitation and treatment strategies Cat. 4: Rhythm, groove Cat. 11: Disorder Cat. 12: Rehabilitation Cat. 17: Synchronization	To review some treatment strategies that could help optimize the sensory cues used in Parkinson' disease (PD) gait rehabilitation	Examining participants' motor system activity while listening to high-groove versus low-groove music, and listening to rhythmic sequences consisting of simultaneous high- and low-pitched piano tones CR: Western popular	1) Tests compared a) walking with an interactive metronome that adapts to the person's steps b) walking with a fixed-tempo metronome c) walking in silence. 2) Investigations by means of transcranial magnetic stimulation (TMS) and mismatch negativity (MMN)	High-groove music is created by the addition of syncopated rhythms to a steady beat pattern. It elicits a strong desire to move. Bass-frequency tones are associated with movement and provide strong timing cues	Adaptive metronomes synchronized with PD patients' footsteps improve stability and reinstate healthy gait dynamics. Lower-pitched tones have a strong influence on the perception of timing and auditory-motor synchronization
16. Furuya and Altenmüller (118-124) Acquisition and reacquisition of motor coordination in musicians Cat. 11: Disorder Cat. 12: Rehabilitation	To provide an overview of the behavioral and neurophysiological basis of motor virtuosity and disorders in musicians, such as task-specific tremor and focal dystonia	An overview of research. No references to particular musical material. CR: -	For treatment of hand dystonia in pianists, recent studies combined bihemispheric transcranial direct current stimulation (tDCS) and motor rehabilitation	It is important to compare effects of different intervention techniques, such as sensory and motor retraining, tDCS, injection of botulinum toxin, and prescription of medications	Transcranial stimulation intervention is a promising tool for musicians' dystonia. However, future studies should address its underlying neurophysiological mechanism
17. Ullén et al. (125-129) Associations between motor timing, music practice, and intelligence studied in a large sample of twins Cat. 4: Timing Cat. 10: Training	To study associations among isochronous serial interval production (ISIP), music practice and intelligence in a large twin cohort. Hand/finger movements with a regular beat (ISIP) is used as a measurement of motor timing skill	Stimulus for tapping task is not indicated. No cultural references. CR: -	7019 individuals participated. Motor timing measurement: Tapping in synchrony with a regular beat (ISIP), continuing when the sounds cease. Music practice estimation by means of a questionnaire. Intelligence measurement by the Wiener Matrizen Test.	Co-twin control design using intrapair differences: Whether phenotypic associations between music practice and motor timing reflect causal influence of practice, or rather underlie common genetic liability	1) Music practice in the general population is related to more stable ISIP per-formance. 2) Effects of music practice and intelligence on motor timing are additive. 3) Twin study: motor timing skills do not reflect causal influences of practice

Dance and the brain: a new window into the study of brain plasticity

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
18. Kirsch et al. (130-139) Dance experience sculpts aesthetic perception and related brain circuits Cat. 16: Audiovisual Cat. 17: Sensorimotor Cat. 18: Bodily impact	To investigate how learning to embody an action impacts the neural response when watching and aesthetically evaluating the same action	Eight dance sequences from the game *Dance Central 2*. CR: Western popular	Twenty-two unskilled participants trained for 4 days on dance sequences. Each day they physically rehearsed one set of sequences, passively watched another set, listened to the music of a third set, and a fourth set remained untrained. fMRI was obtained before and after training, as were affective and physical ability ratings for each dance sequence	Central hypothesis: Increased experience with a previously unfamiliar action should increase liking, and such changes will be reflected by modulation of Action Observation Network (AON) activity.	Results suggest that after experience, participants most enjoy watching those dance sequences they danced or observed. Brain regions involved in mediating the aesthetic response shift from subcortical regions associated with dopaminergic reward processing to posterior temporal regions involved in processing multisensory integration, emotion and biological motion.
19. Karpati et al. (140-146) Dance and the brain: a review Cat. 10: Training Cat. 16: Audiovisual Cat. 17: Sensorimotor	To provide a critical summary of work investigating the neural correlates of dance	Reviewed studies include classical ballet, tango, Brazilian capoeira dance, and dance video games. CR: Cross-cultural	The review includes fMRI and EEG studies of dance observations, and a PET study of dancers performing tango steps with their legs. Functional near-infrared spectroscopy (fNIRS) has been used to study brain activity while subjects performed a dance video game.	To stimulate ongoing dialogue between dance and science by discussing future directions in dance and brain research	Studies on dance observation suggest that long-and short-term dance training affects brain activity in the action observation network, which may be involved in action simulation. Preliminary work suggests that long-term dance training changes both gray and white matter structure in the brain

Musical expertise and more?

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
20. Moreno and Farzan (147-152) Music training and inhibitory control: a multidimensional model Cat. 10: Training Cat. 13: Cognition	To propose a framework of transfer effects characterized by three dimensions: level of processing, nature of the transfer, and involvement of executive functions	A music training program for 5-year old children, including rhythm, pitch, melody, voice, and basic musical concepts. CR: Western	1) EEG study of executive functioning of musicians, bilinguals, and nonmusician monolinguals. 2) EEG: comparison of a music training program and a visual arts training program. 3) MMN: comparison of the music training program and a language training program	The possibility that inhibitory control (IC) of executive functions could be the main factor mediating transfer of skills between cognitive abilities	Results support that music training can serve as a potential solution to improve cognitive abilities. The presented research indicates a link between music training and inhibitory control
21. Putkinen et al. (153-162). Promises of formal and informal musical activities in advancing neurocognitive development throughout childhood Cat. 6: Speech Cat. 9: Development Cat. 10: Training	To examine how formal musical training and less formal musical activities influence the maturation of brain responses related to sound discrimination and auditory attention	One MMN study: Six-tone melodies played with a piano timbre, displaying changes in melody, rhythm, musical key, timbre, tuning and timing. A related study employs highly salient environmental sounds to elicit P3a responses. CR: Western	Two longitudinal studies of children, N = 133 and 117. EEG measurements including MMN one to four times every 2 years between the ages of 7 and 13 years, comparing a group of musically trained children and a control group	Whether superior neural sound discrimination in adult musicians reflects the effects of experience or preexistent neural enhancement in individuals who seek out musical training	Relative to the control group, the musically trained children became gradually more sensitive to various types of sound changes as indexed by the MMN. This appeared to be caused by training and not to reflect preexisting group differences
22. Kraus and Strait (163-169). Emergence of biological markers of musicianship with school-based music instruction Cat. 6: Speech. Cat. 9: Development Cat. 10: Training	To examine the emergence of neural markers of musicianship in children and adolescents using longitudinal approaches to track the development of biological indices of speech processing	Stimulus material: Speech sounds. No references to a particular musical culture. CR: -	Longitudinal designs in children and adolescents, measuring the effects of two years of group music training, observed in the plasticity of automatic sound processing, specifically in neural responses to speech	Automatic sound processing, accessed through the auditory brainstem response to complex sounds (cABR) in the inferior colliculus (IC) which provides a site of convergence for bottom-up and top-down innervations	Children who underwent music training for 2 years developed faster neural responses to speech syllables and demonstrated better reading and speech-in noise perceptions than their untrained peers
23. Schellenberg (170-177) Music training and speech perception: a gene-environment interaction Cat. 6: Speech Cat. 7: Culture Cat. 9: Development Cat. 10: Training	A critical discussion of claims of beneficial side effects of music training for many different abilities, including verbal and visuospatial abilities, executive functions, working memory, and speech perception in particular	In the review of many studies, musical material is rarely specified. One reviewed study indicates the use of Western and Indian classical music. CR: Cross-cultural	A discussion of evidence that points to a contribution of genetics to aptitude, versus research that interprets correlational results as indicating that music lessons make one a better listener and perceiver of speech	Recent evidence indicates that the role of genetics in music aptitude and music achievement is much larger than previously thought	Music training is an ideal model for the study of gene-environment interactions but far less appropriate as a model for the study of plasticity. The results of Kraus et al. (No. 22 above) have no behavioral counterpart

The role of music in promoting infants' well-being: clinical and research perspectives

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
24. Loewy (178-185) NICU music therapy: song of kin as critical lullaby in research and practice Cat. 4: Rhythm Cat. 5: Song Cat. 12: Therapy Cat. 18: Bodily impact	To examine how music therapy during neonatal intensive care unit (NICU) stay can improve neonatal function and reduce anxiety in parents	Music in different studies: Live elements of music including rhythm, breath and parent-preferred lullabies (songs of kin, representative of parent culture). Well-known lullabies. Ocean drum, gato box (a wooden rhythm instrument meant to simulate a heartbeat sound) CR: Cross-cultural	One particular study over 2,5 years: Lullaby interventions provided by the parent or the music therapist, comparing song of kin to the use of the standard popular lullaby "Twinkle, Twinkle". Measurements of heart rate, respiration, oxygen saturation, sleep patterns, and sucking rate	Unlike a recording of music, music therapy fosters a live, direct means of entrainment, particularly when supported through a parent-infant application	Culturally based, parent-selected, personalized musical tunes provided in song, as a noninvasive intervention, foster optimal, continuous quality of care. Music therapy involving the parents can make parents more fully resilient in attending to their infants
25. Trehub et al. (186-192) Musical affect regulation in infancy Cat. 4: Rhythm Cat. 5: Song Cat. 19: Emotion	To describe recent laboratory research that explores the consequences of singing for infant affect regulation	Maternal singing and speech, play songs and lullabies from various cultures. Infant-directed and non-infant-directed singing by unfamiliar singers. CR: Cross-cultural	Review of various studies. (1) One study: exposing 6-9-month-old infants to three audio recordings: A rhythmic Turkish play song, the words of the song spoken in an infant-directed manner, and the words spoken in a neutral manner (2) Studying affect regulation in 10-month-old infants with stress-inducing perturbations such as the still-face procedure	The effect of singing versus the effect of speech	(1) Listening to recordings of infant-directed singing can prolong positive or neutral affect and delay visible signs of distress. (2) After inducing distress and heightened arousal in infants by the mother's face being unresponsive for 15 sec., maternal singing was more effective in ameliorating distress than maternal speech. Lively play songs were most effective

Music and emotion: implications for therapy and rehabilitation

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
26. Koelsch (193-201) Music-evoked emotions: principles, brain correlates, and implications for therapy Cat. 12: Therapy Cat. 13: Expectation Cat. 14: Memory Cat. 19: Emotion	To describe seven principles underlying the evocation of emotion with music: evaluation, resonance, memory, expectancy/tension, imagination, understanding, and social functions	Overview of many studies. Analytical comments refer to tonal music. CR: Western	Discussion of the seven principles in relation to neuroscience and music therapy. 71 references.	The term *principle* is used instead of *mechanism* or *rules*, because the emotional effect of music is variable. Several of the principles and subprinciples underlying the evocation of emotion with music have not been investigated empirically yet	The presented framework is supposed to provide a starting point for a systematic, coherent, and comprehensive theory on music-evoked emotions that considers both reception and production of music, and the relevance for music therapy
27. Zatorre (202-211) Musical pleasure and reward: mechanisms and dysfunction Cat. 11: Deficits Cat. 17: Sensorimotor Cat. 18: Bodily impact Cat. 19: Emotion	To explore individual differences in the way the dorsal and ventral striatum interact with cortical mechanisms involved in perception and valuation of musical stimuli	Overview of many studies on music, reward processing, and valuation. References include classical and popular genres. CR: Western, Western popular	Discussions of Mechanisms of reward, Music and reward processes, Music and anhedonia. Development of a questionnaire has allowed the identification of factors associated with musical pleasure: music-seeking, emotion-evocation, mood regulation, sensorimotor, and social factors.	Informational crosstalk between the systems responsible for pattern analysis and prediction (cortical) with the systems responsible for assigning reward value (subcortical). Reward prediction errors are related to dopamine neurons in the midbrain and the striatum	Music reward may depend to a greater extent on cortical mechanisms than other more basic ones. A novel finding: 5 % of a studied population show low sensitivity to musical reward, but normal sensitivity to other rewarding stimuli
28. Vuilleumier and Trost (212-222) Music and emotions: from enchantment to entrainment Cat. 13: Attention Cat. 17: Entrainment Cat. 19: Emotion Cat. 20: Musical expression	To review the similarities and differences in the neural substrates underlying ”complex” music-evoked emotions, such as feelings of wonder, nostalgia, transcendence or tenderness, compared to other more ”basic” emotional experiences, such as joy or sadness	Twenty-seven 45-sec excerpts of classical music, including 20th century composers, that were carefully chosen to elicit specific kinds of aesthetic emotions. CR: Western, Western 20th Century	Examining brain activity patterns with fMRI while amateurs listened to a variety of classic music pieces. After each music piece, participants rated whether they felt any of the nine emotion categories *wonder, tenderness, nostalgia, tension, power, peacefulness, joyful activity, sadness, and transcendence* (i.e. feelings related to sacred or divine domains), and rated *valence, arousal,* and *familiarity* of the music	To explore the richness and originality of music-specific emotions. The nine categories can be regrouped under higher order factors such as vitality, unease, and sublimity (defined as a sense of beauty and perfection)	Research suggests that ”complex” music–evoked emotions emerge through activation in emotional and motivational brain systems that confer valence to music, combined with activation in several other areas, including motor, attention, or memory-related regions. The dimensions valence and arousal are relevant for describing complex as well as more basic emotions

Music cognition in dementia

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
29. Cuddy et al. (223-231) Preservation of musical memory and engagement in healthy aging and Alzheimer's disease Cat. 11: Deficit Cat. 14: Memory Cat. 19: Emotion, mood	To review evidence for spared musical long-term memories in aging and Alzheimer's Disease (AD)	Familiar melodies well-known by study participants. CR: Western, Western popular	Tests: Recognition of familiar and famous melodies. Detection of pitch errors in familiar melodies. Ability to sing a continuation of a song, prompted by spoken lyrics. Spontaneous recollection of memories evoked by music	Data provided by a Musical Engagement Questionnaire which assesses behavioral responses to music and is answered by the care partner	Persons with mild to moderate AD preserve musical engagement and music seeking. Familiar music evokes autobiographical memories for healthy older adults and for those with mild to moderate AD
30. Agustus et al. (232-240) Functional MRI of music emotion processing in frontotemporal dementia Cat. 11: Deficit Cat. 19: Emotion	To assess brain mechanisms of music emotion processing in patients with frontotemporal dementia in relation to healthy age-matched individuals	Different elements: Four-note arpeggio major and minor chords and their dissonant versions, synthesized in string instrument timbre; male and female vocalizations: laughter and crying. CR: Western	fMRI of fifteen patients and eleven healthy age-matched individuals. Scanning during listening to different configurations comprising five elements, each 1,5 sec. Plus post-scan behavioral assessment of music perception	To indicate the potential of music to delineate neural mechanisms of altered emotion processing in dementias. Special interest in six patients with abnormal craving for music (musicophilia)	A complex profile of disease-associated functional alterations was identified within a common, distributed brain network. Limitation: The study was based on passive listening to generic emotional stimuli with a relatively simple structure
31. Halpern et al. (241-248) Musical tasks targeting preserved and impaired functions in two dementias Cat. 1: Pitch. Cat. 3: Timbre Cat. 11: Deficit Cat. 13: Cognition Cat. 14: Auditory imagery	To explore specific aspects of music cognition 1) in patients suffering from Alzheimer's disease (AD), 2) in patients suffering from Lewy body disease (LBD), compared to age-matched healthy controls	1) AD: Imagery task: Well-known tunes. 2) LBD: Musical dimension task: Pitch and timbre judgments. Stimuli: Three possible pitches and seven different sampled instruments. CR: Western	1) AD task: to judge whether a tune was familiar or unfamiliar. 2) LBD task: Question after presentation of a sound pair: Was the instrument/pitch of the notes the same or different?	1) AD: whether musical imagery is spared in early stages of the illness. 2) LBD: whether executive dysfunction would extend to music	Preliminary results: AD imagery task: Patients score similarly to controls. LBD musical dimension task: Patients are impaired relative to controls
32. Samson et al. (249-255) Efficacy of musical interventions in dementia: methodological requirements of non-pharmacological trials Cat. 11: Deficit Cat. 12: Therapy Cat. 19: Emotion	To carry out two randomized controlled trials (RCT) to compare the effectiveness of musical activities to other pleasant activities on various functions in patients with severe Alzheimer's disease (AD)	Music interventions: listening, clapping hands or singing with music. Various styles: classical, traditional, commercial. CR: Western, Western popular	Study 1 and 2: Patients engaged in either music or cooking activities during eight sessions, alternating between receptive (listening to music, tasting recipes) and productive phases (clapping and singing, preparing a recipe). Assessment of discourse, facial expressions, and mood	To report and discuss two successive studies to illustrate how methodological weaknesses might bias results by amplifying the effect of a music intervention, thus warning against a lack of experimental rigor	In study 2, all assessors (interviewer, psychologist, caregivers, and raters) were blinded from the patient's group affiliation. Contrary to study 1, this study showed that both music and cooking interventions resulted in improved emotional state in the patients

Musical applications: workshops

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
33. Magee and O'Kelly (256-262) Music therapy with disorders of consciousness: current evidence and emergent evidence-based practice Cat. 3: Noise Cat. 11: Disorder Cat. 12: Therapy Cat. 18: Bodily impact	To present the latest evidence for using music as a diagnostic tool with Prolonged disorders of consciousness (PDOC), including recent developments in music therapy interventions and measurements	Music therapy procedures (live preferred music and music entrained to respiration), disliked music, and white noise CR: Western, Western popular	Basis for the investigation was the Music Therapy Assessment Tool for Awareness in Disorders of Consciousness (MATADOC). Responses to silence, music therapy procedures, disliked music and white noise were compared in 20 healthy, 12 Vegetative State (VS), and 9 Minimally conscious state (MCS) individuals	Preserved auditory responsiveness may exist in the absence of motor response in PDOC populations in response to verbal commands, the subject's own name, and musical tones	Recent research illustrates a range of benefits of music-based methods at behavioral, cardiorespiratory, and cortical levels using video, electrocardiography, and electroencephalography methods
34. Loui et al. (263-271) Neurological and developmental approaches to poor pitch perception and production Cat. 1: Pitch Cat. 5: Song Cat. 11: Deficit	To explore the problems of poor pitch perception and production from both neurological and developmental/educational perspectives	The Seattle Singing Accuracy Protocol (SSAP) procedures: Pitch discrimination, Acoustic range-finding, Echo-singing tasks, Song-singing tasks CR: Western	1) Comparison of white-matter structures in the brains of amusic and matched control subjects 2) Presentation of the SSAP as a tool for measuring singing accuracy	To translate basic music research into clinical and educational applications. To create a rich description of the process of singing development in both typically developing and disordered populations, and to identify strategies to help those who experience difficulties	Findings suggest that amusia is a neural disconnection syndrome in which areas of the brain that are important for pitch production are poorly connected with areas important for conscious access of perceptual information

The Neurosciences and Music VI: Music, Sound, and Health. Conference 15-18 June 2017 in Boston, USA

A survey of the 41 papers in the conference proceedings:
***Annals of the New York Academy of Sciences*, Volume 1423 (July 2018)**
edited by Psyche Loui, Aniruddh Patel, Lisa M. Wong, Nadine Gaab, Suzanne B. Hanser, and Gottfried Schlaug

Contents:

The survey presents, in brief and schematic form, for each paper:

Abbreviated title as indicated in the conference proceedings, with page numbers.
Categories of investigation
Aim of the study
Musical material and Cultural references
Technology and Procedure
Main focus of interest
Conclusion

Perspectives (1-6)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
1. Elmer and Jâncke (10-18) Relationships between music training, speech processing, and word learning: a network perspective Cat. 6: Language Cat. 10: Learning	To extend previous findings of functional and structural changes in the auditory cortex (AC) to a network perspective	No particular musical material. A body of electrophysiological studies indicate measurements of responses to consonant-vowel syllables manipulated in terms of voice-onset time, pitch, or duration. CR: -	Studies combining fMRI, Diffusion Tensor Imaging and EEG show how functional and structural connectivity can be used to model simple neural circuits exerting a modulatory influence on AC activity	To propose a new framework for extending previous findings to a network perspective by integrating multimodal imaging, electro-physiology and neural oscillations	A network approach can be used for better comprehending the beneficial effects of music training on complex speech functions
2. Vuust et al. (19-29) Now you hear it: a predictive coding (PC) model for understanding rhythmic incongruity Cat. 4: Timing, groove Cat. 13: Prediction Cat. 18: Bodily impact	To discuss brain processing of rhythm, and to present a Predictive Coding of Rhythmic Incongruity (PCRI) model which proposes that rhythm and meter processing is based on priors, predictions, and prediction error	A series of studies used a battery of 50 groove-based drum patterns, 34 transcribed from real funk tracks, 16 constructed for the experiment, aiming for a continuum from weakly syncopated to strongly syncopated patterns. CR: Western popular	In some studies, musicians and non-musicians listened to syncopations in musical drum rhythm excerpts during magnetoencephalography (MEG), measuring event-related potentials: mismatch negativity (MMN) and the P3a component, known as the novelty P3	In PC, top-down connections provide lower levels with predictions in the form of prior expectations about the states of the world, and bottom-up connections carry prediction errors that update posterior expectations in higher levels to provide better predictions	Some results suggest that the P3a reflects a neural network that acts on the error signal of the MMN. The PCRI model can explain prominent features of brain processing of syncopation, and the urge to move to grooves with a medium level of syncopation
3. Trainor et al. (30-39) Is auditory perceptual timing a core deficit of developmental coordination disorder? Cat. 4: Timing Cat. 11: Disorders Cat. 17: Sensorimotor	To propose directions for investigating auditory perceptual timing processing in “clumsy” children suffering from Developmental Coordination Disorder (DCD)	Tests consider both duration timing, measured in terms of discrimination of filled or unfilled intervals, and beat-based timing which can be tested in tapping and clapping tasks. CR: Neutral	It would be informative to use fMRI, EEG and MEG to examine how auditory time processing activates motor brain regions in DCD children, and how the activation patterns relate to the children’s behavior	Characteristics of DCD, such as difficulties in motor learning, motor planning, adapting to change, and sequencing of movements rely on timing, temporal prediction, and being able to learn from timing errors	Auditory timing deficits may be core characteristics of DCD. Further research can benefit the understanding of the etiology of DCD, identify biomarkers of DCD, and contribute to develop interventions for DCD
4. Zuk and Gaab (40-50) Evaluating predisposition and training in shaping the musician’s brain: the need for a developmental perspective Cat. 8: Musicians Cat. 9. Child development Cat. 10: Training	To consider factors that may contribute to early brain structure prior to formal musical training, and to introduce a model for potential neurobiological pathways leading to the characteristic “musician’s brain”	No particular musical material. CR: -	Numerous studies of brain structures comparing musicians to non-musicians, including fMRI studies of gray matter differences and Diffusion Tensor Imagining (DTI) studies of white matter connections	To make an argument for the significance of utilizing a developmental perspective and longitudinal designs to advance the understanding of the impact of musical training on brain structure	Evidence suggests that musical training can lead to broad alteration in brain organization, and reorganization of specific brain regions, plus subsequent neuroplasticity changes in functional and structural networks

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
5. Honing (51-56) On the biological basis of musicality Cat. 1: Pitch, intervals Cat. 4: Timing, rhythm, meter Cat. 9: Development	To introduce a research program about the structure of musicality, not the structure of music. The program combines functional, developmental, phylogenetic, and mechanistic approaches	Potential candidates for the basic components of musicality are contour and interval analysis, regularity and beat perception, tonal encoding of pitch, and metrical encoding of rhythm. CR: Western, Birdsong	(1) Research on the auditory system of rhesus macaques, the brains of which have a similar structure as human brains. (2) Research on certain songbirds, such as Zebra finches, that can learn new songs	Hypothesis: Musicality is an innate capacity for music that can be seen as a natural, spontaneously developing set of traits based on and constrained by our cognitive abilities and their underlying biology	A comparative study of musicality in humans and animal models (monkeys, birds, seals) will further our insights on which features of musicality are exclusive to humans and which are shared with nonhuman animals
6. Chen (57-65) Music-supported therapy for stroke motor recovery: theoretical and practical considerations Cat. 11: Deficits Cat. 12: Rehabilitation Cat. 17: Sensorimotor Cat. 19: Emotion, mood	To document and discuss available knowledge and evidence for a role of music in supporting the rehabilitation of movements after stroke, in relation to information about stroke recovery in general	Music-Supported Therapy (MST): Active music-making on drum pads and keyboards, and Rhythmic Auditory Stimulation (RAS). CR: Western, W. popular	MST, RAS, and other rehabilitation approaches: mirror therapy, constraint-induced movement therapy, motor imagery, robotics, virtual reality. Randomized Controlled Trials (RCT) indicate effects of different approaches	Whether research has fully and convincingly evaluated the active ingredients of MST, such as auditory-motor coupling and music's impact on arousal and affect. Furthermore, differences in patients' response to MST	Systematic reviews suggest that RAS and music making may improve some aspects of upper and lower limb movements. However, the reviews found the quality of evidence to be highly biased

Concise Review (7)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
7. Cirelli et al. (66-72) Rhythm and melody as social signals for infants Cat. 4: Timing, meter Cat. 5: Song Cat. 9: Child development Cat. 17: Entrainment, synchronization	To discuss recent studies of the influence of musical engagement on infant social cognition and behavior	Familiar, caregiver-taught songs. Synchronous singing and music-making. Exposure to music with non-Western and Western metrical structure. CR: Cross-cultural	Studies include synchronous singing, tapping, clapping and moving. Infants bounced in and out of synchrony. Infant-directed song which is higher in frequency, more emotionally expressive, and slower and more regular in tempo	Multimodal, interactive musical experiences are likely to have greater impact on infants than passive exposure to recorded music. Young infants demonstrate perceptual flexibility, being able to learn foreign metrical structures	Infants use interpersonal synchrony and song familiarity to selectively direct their social behavior. When caregivers hold infants and gently rock them while singing a familiar song, they are conveying complex sensory, social, and affective information

Reviews (8-17)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
8. Habibi et al. (73-81) Music training and development: a review of recent findings from a longitudinal study Cat. 9: Child development Cat. 10: Training Cat. 13: Cognition	To investigate the effects of music training on children's brain and cognitive development, as part of an ongoing longitudinal study	Training for two years: Music group: Free instruction 6-7 hours weekly. Sports group: Free soccer training three times a week, or free swimming instruction twice a week. CR: Western, W. popular	68 children from low-income underprivileged areas of Los Angeles. 21 enrolled a music-training program, 23 a sports training program, 24 no systematic training. Pre- and post-project behavioral tests and fMRI sessions	Changes in cortical volume and cortical thickness, changes in the Corpus Callosum, and differences observed in a network of brain regions known to be involved in response inhibition	Music training induces brain and behavioral changes in children, and those changes are not attributable to pre-existing biological dispositions for musicality. A report after four years of training will follow
9. Järvelä (82-91) Genomics studies on musical aptitude, music perception and practice Cat. 1: Pitch Cat. 4: Timing Cat. 13: Cognition Cat. 22: Genomics	To search for genetic markers inherited together with musical aptitude in subjects with no specific music education	Tests of musical aptitude: (1) The Karma Music Test (KMT), measuring the recognition of melodic contour, grouping, relational pitch processing, and gestalt principles. (2) The Seashore tests for pitch (SP) and for time (ST). CR: Western, Birdsong	76 families were defined for musical aptitude by the KMT, SP and ST tests. Next, DNA from each participant was tested for 660,000 different single-nucleotide polymorphisms (SNPs) located in the human genome	Genes linked to dopamine metabolism, such as the alpha-synuclein gene (SNCA) and GATA2 which regulates SNCA, as well as genes shared by humans and songbirds	Regions for positive selection with musical aptitude contained genes affecting auditory perception, cognitive performance, memory, reward mechanisms, and the song perception and production of songbirds
10. Virtala and Partanen (92-101) Can very early music interventions promote at-risk infants' development? Cat. 5: Song Cat. 6: Language Cat. 9: Child development	To review findings on the possible effects of music in supporting auditory and language development in healthy children, and to present interventions for at-risk children	Studies by the authors: DyslexiaBaby (DB): Finnish children's and folk songs in vocal and instrumental versions. Singing Kangaroo (SK): Parents sing or hum songs and melodies of their own choosing. CR: Western, W. traditional	DB: Music listening intervention from birth until 6 months of age. Auditory measurements of language response with EEG at birth, at 6 months and 2.5 years. SK: measurements similar to DB	Promoting the neurocognitive development of at-risk children, with a focus on two conditions: familial risk for developmental dyslexia and premature birth	Preliminary results of the authors' longitudinal studies suggest that music making and parental singing promote infants' early language development and auditory neural processing
11. Noppeney and Lee (102-116) Causal inference and temporal predictions in audiovisual perception of speech and music Cat. 6: Language Cat. 13: Prediction Cat. 16: AV integration	To review studies of audiovisual (AV) integration and segregation for speech and music processing	One example: the "pluck and bow illusion": in a video presentation, an actor plucks or bows a cello, and a range of auditory signals morph successively from a sound of a pluck into a sound of a bow stimulus. CR: Western, W. popular	A summary of multiple studies documents the effect of long-term music training on perception of audiovisual speech and music. Long-term music expertise renders observers more sensitive to temporal misalignments	Prior expectations based on lifelong exposure to natural speech and music stimuli mold a fine-tuned internal model that enables the brain to predict the temporal relationship of auditory and visual signals	For music and speech perception, temporal regularities are critical cues informing the brain whether signals are caused by common sources and should be integrated into a unified percept

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
12. Putkinen and Saarikivi (117-125) Neural correlates of enhanced executive functions: is less more? Cat. 8: Musicians Cat. 13: Cognition Cat. 14: Memory	To investigate how proficient performance in executive function (EF) tasks is reflected in brain activity	No use of musical material. Tests include inhibition tasks: Stroop and go-no go. Working memory tasks: n-back. Set-shifting tasks involving switching between response strategies. CR: -	Part of a longitudinal study: 26 musically trained, 23 non-musicians, aged 16-21 years. fMRI scanning during non-musical visual inhibition tasks and set-shifting tasks	Proficient cognitive performance is often reflected in decreased activation in structures underpinning EF, including the frontal lobe and parietal regions	Preliminary results suggest that musically trained adolescents recruit frontoparietal regions less strongly during EF than untrained peers
13. Albouy et al. (126-137) Driving working memory with frequency-tuned noninvasive brain stimulation Cat. 1: Melody Cat. 14: Memory	To review the impact of frequency-tuned noninvasive brain stimulation on the research field of human working memory (WM), reporting the main behavioral and neurophysiological outcomes	Studies by the authors employed two WM tasks: a simple melody-comparison task and an active mental-reversal task (manipulation task). CR: Western	Relevant techniques: Rhythmic transcranial magnetic stimulation (TMS), oscillatory transcranial direct current stimulation (otDCS), transcranial alternating current stimulation (tACS), combined with MEG and EEG	Noninvasive brain stimulation techniques are considered tools to investigate the causal relationship between brain and behavior. The behavioral outcome of these techniques needs to be interpreted in the context of network effects	Studies by the authors indicate that theta-band activity (4-8 Hz) can be manipulated with tACS and rhythmic TMS and is directly related to working memory performance
14. Loui (138-145) Rapid and flexible creativity in musical improvisation: review and a model. Cat. 1: Melody Cat. 8: Musicians Cat. 17: Sensorimotor Cat. 21: Improvisation	To provide an overview of research in neuroscience of musical improvisation, especially focusing on multimodal neuroimaging studies	fMRI studies include improvising jazz musicians and classically trained pianists, freestyle rap improvisation, and "daydreaming" associated with resting brain activity. CR: Western, W. popular	Review of studies reporting the use of fMRI, Voxel-based morphometry (VBM), Diffusion Tensor Imaging (DTI), and Event-related potentials (ERP)	The interplay of idea generation and evaluation likely entails the coordinated activity of the default mode and executive control networks in the brain	Research informs a model of creativity as a coordination of generative and reactive processes to give rise to novel and aesthetically rewarding improvised musical output
15. Huotilainen and Tervaniemi (146-154) Planning music-based amelioration and training in infancy and childhood based on neural evidence Cat. 6: Language Cat. 9: Child development Cat. 10: Training	To present the available evidence showing that music-related activities result in positive changes in brain structure and function, becoming helpful for auditory cognitive processes in everyday life situations	Different types of musical activity are discussed, including learning to play classical music, musical playschools, and listening to heavy metal or Latin American music. CR: Cross-cultural	Longitudinal studies have investigated brain development in children starting a musical hobby in several stimulation paradigms. EEG Tests of children at 7 and at 9 years showed enhanced brain responses in the music group compared to a control group	To take a critical position on the studies so far and their error sources. Positive effects of music training appear to be contaminated with publication bias.	Music-based training is beneficial generally and is especially important in cases of dyslexia, learning and language disabilities. Unfortunately, studies are affected by issues and biases that make the results less generalizable or less reliable

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16. Caclin and Tillmann 155-165) Musical and verbal short-term memory: insights from neurodevelopmental and neurological disorders Cat. 6: Language Cat. 11: Disorders Cat. 14: Memory	To review studies that have investigated both musical and verbal short-term memory (STM) in healthy individuals and in participants with neurodevelopmental and neurological disorders	Many comparisons of musical pitch vs. verbal syllables. A few comparisons of (1) musical pitch and timbre vs. verbal syllables, (2) musical pitch vs. verbal pitch, (3) musical sequences vs. verbal sequences. CR: Neutral	In a summary of 18 studies comparing musical and verbal STM, 13 studies report behavioral measures, 3 report fMRI data, one EEG data, and one functional Near-Infrared Spectroscopy (fNIRS) data	Whether separate STM systems exist for different types of auditory information (music and speech, in particular) is a matter of debate	Overall, the results of reviewed studies are in favor of only partly shared networks for musical and verbal STM. There is a need for studies comparing STM for the same perceptual dimension in music and speech
17. Ozernov-Palchik and Patel (166-175) Musical rhythm and reading development: does beat processing matter? Cat. 4: Rhythm, meter Cat. 6: Language Cat. 13: Prediction	To review and discuss child studies on links between rhythm processing and reading-related skills	Tasks in various child studies: same/different rhythm discrimination; tempo discrimination; which of two tone pairs had the "longer gap"; meter perception; regularity detection. CR: Western, W. popular	The authors' study of 74 children, mean age 5.8 years: in a tablet-based app, children listen to two short rhythmic patterns and decide whether they are same or different. Ten trials of beat-based and ten trials of non-beat-based patterns. Comprehensive tests of language and cognitive measures	Musical rhythm is often beat-based (based on an underlying grid of time intervals), while speech rhythm is not. Does beat-based processing in music have a distinct relationship to reading-related cognitive processing?	The authors propose that beat-based processing taps into a listener's ability to use rich contextual regularities to form predictions, a skill important for reading development

Concise original report (18)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
18. Ravigniani et al. (176-187) Evolving building blocks of rhythm: how human cognition creates music via cultural transmission Cat. 4: Rhythm, meter Cat. 7: Cultural influence	To address the question of how individual cognitive biases affect the process of cultural evolution in music, reporting behavioral experiments and adapting computational techniques to the interpretation of human data	First experiment: An initially random drumming pattern is given to a participant, who transmits the pattern to another participant to imitate. The patterns are transmitted in chains of six "generations" of learners. CR: -	Participants in the authors' first experiment: 48 non-musician students, average 23 years. Data from this experiment were reanalyzed. In a new experiment, data were collected in comparable conditions, and this experiment also included that the same participant listened and imitated his/her own drum patterns	The *nativist hypothesis*: human cognition is constrained to produce only certain forms of music and musical structure, versus the *interactive hypothesis*: the structure in music results from long-term distributed effects of multiple, individually varying minds that together create a kind of structural compromise that is pleasing to and learnable by all	Participants' biases are amplified by cultural trans-mission, making drumming patterns more structured. Results suggest that rhythmic structure results from a balance between individuals imprinting their biases and interactive transmission among listeners, learners, and performers. Thus, the results support the *interactive hypothesis*

Original articles (19-41)

Title, Category	Aim	Mus. Material, Cultural Ref.	Technology & Procedure	Main focus of interest	Conclusion
19. Tseng et al. (188-197) Correlation of vocals and lyrics with left temporal musicogenic epilepsy Cat. 1: Melody Cat. 5: Song Cat. 6: Language Cat. 11: Disorders	To investigate the triggering factors in musicogenic epilepsy (ME), a rare form of epilepsy in which recurrent seizures are triggered by listening to music	Different types of music (popular, instrumental, classical), instruments (vocal, piano, violin) and languages (Mandarin, Taiwanese, English, Japanese). CR: Western, W. popular, Asian	Three patients listened to a playlist of 10-15 songs and instrumental pieces during continuous recording of EEG and video. EEG analysis of music-induced seizures was conducted	Potential triggering effects of human voice and lyrics. Brain location of the triggered seizure	All patients had sound-triggered left temporal seizures in response to popular songs with vocals, but not to piano solo versions of the same song. Sentimental lyrics, high-pitched singing and native language were significant triggering factors
20. Müller et al. (198-210) Hyperbrain network properties of guitarists playing in quartet Cat. 8: Musicians Cat. 17: Synchronization	To explore the extent and the functional significance of synchronized cortical activity across four musicians' brains	Two pieces for guitar quartet: *Libertango* by Astor Piazzolla and *Comme un Tango* by Patrick Roux. CR: Latin American, Western	Simultaneous EEG recordings of four professional guitar players while playing the two music pieces	To identify two different types of information flow: within-brain connectivity and between-brain connectivity	Hyperbrain networks are unstable and change their structure over time. The hyperbrain networks show small-world topology
21. Furuya et al. (211-218) Probing sensorimotor integration during musical performance Cat. 8: Musicians Cat.17: Sensorimotor	To propose two novel techniques to investigate the roles of auditory and proprioceptive feedback in piano performance	Experiment (1): Striking two piano keys, C3 and D3. Experiment (2): Striking five piano keys, C B A G F. CR: -	(1) A noninvasive brain stimulation consisting of transcranial magnetic stimulation and a motion sensor. (2) A system capable of manipulating the weight of a piano key	(1) To assess cortical processes subserving auditory-motor integration, and (2) to characterize movement adaptation based on loudness feedback	The techniques contribute to characterizing computational and neural processes of sensorimotor integration in piano performance
22. Wiens and Gordon (219-228) The case for treatment fidelity in active music interventions: Why and how Cat. 6: Language Cat. 11: Deficits Cat. 12: Therapy	To highlight and discuss fidelity elements in music treatment designs, vital for providing evidence for the improvement of language skills	A novel music intervention for children with specific language impairment (SLI), the Music Impacting Language Expertise (MILEStone) applied a 20-week Suzuki violin lesson program. CR: Western	Pilot study: Two children with SLI. The design includes a behavioral coding system, a treatment manual, activity checklists, provider training and monitoring, a home practice log, and teacher ratings of participant engagement	To sufficiently address treatment fidelity, four elements should be reported: treatment design, provider training, treatment administration, and receipt of treatment by the participants	The MILEStone takes a first step in modeling a formalized procedure for assessing treatment fidelity in active music-making intervention research

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23. Chenausky and Schlaug (229-241) From intuition to intervention: developing an intonation-based treatment for autism Cat. 6: Language Cat. 11: Disorders Cat. 12: Therapy	To discuss considerations to take into account when developing a music-based intervention for a core symptom of autism, including treatment modality, assessment of the behavior to be treated, and outcome measures of the treatment	In auditory-motor mapping training (AMMT) for minimally verbal (MV) children with autism, syllables are intoned using two pitches. At the same time, therapist and child tap electronic drums tuned to the same pitches, one tap per syllable. CR: Neutral	A series of studies compare the AMMT treatment to another validated treatment, the speech repetition therapy (SRT)	To investigate the effect of simultaneous intonation and drumming, the "active ingredients" of AMMT, in controlled trials	Music-based interventions may provide a unique avenue for improving language in minimally verbal children with autism spectrum disorder (ASD) by engaging them in enjoyable turn-taking activities
24. Degé and Kerkovius (242-250) The effects of drumming on working memory in older adults Cat. 6: Language Cat. 10: Training Cat. 13: Cognition Cat. 14: Memory	To investigate the effect of a music training program on working memory (verbal memory, visual memory and central executive processing) in older adults	Music program: singing together, drumming together, playing percussion instruments together. Literature program: Reading and discussing classical literature, short stories, and prose. CR: Western, W. popular	Three groups: Music, n=8. Literature, n=7. Both groups were trained for 15 weeks. Untrained control group, n=9. Pre- and post-tests of cognitive abilities, depression, verbal and visual memory, central executive processing	Potential associations between music training, memory and executive functions	Preliminary evidence: Findings show a possible effect of music training on verbal and visual memory in older people
25. Zamm et al. (251-263) Amplitude envelope correlations measure synchronous cortical oscillations in performing musicians Cat. 8: Musicians Cat. 17: Synchronization	To describe the application of a novel method for measuring two musicians' interbrain synchrony: amplitude envelope (AE) correlations recorded with EEG	The popular melody *Frère Jacques ("Brother John")* performed in unison on electronic keyboards by two pianists as a synchrony task. CR: Western traditional	Simultaneous EEG recordings of each participant, and Musical instrument timing interface (MIDI) recordings of timing information associated with keystrokes	Temporal correlation of cortical oscillations arising from two individuals performing a joint action	Using AE to assess both the temporal structure of music performance and the temporal structure of neural oscillations offers a promising approach to investigating interbrain correspondences in cortical activity during joint action
26. Fujioka et al. (264-274) The effects of music-supported therapy on motor, cognitive, and psychosocial functions in chronic stroke Cat. 11: Deficits Cat. 12: Rehabilitation Cat. 17: Sensorimotor	To investigate effects of music-supported therapy (MST) in chronic stroke on motor, cognitive, and psychosocial functions compared to conventional physical training using the Graded Repetitive Arm Supplementary Program (GRASP)	MST utilizes music-making activities with percussion and keyboard instruments. CR: Western, W. popular	28 adults with unilateral arm and hand impairment were randomly assigned to MST (n=14) and GRASP (n=14), and received 30 hours of training over a 10-week period. Assessment before intervention, after 5 weeks, 10 weeks, and 3 months after training completion	Outcome measures: (1) Chedoke-McMaster Stroke Assessment (CMSA) of hand impairment level. (2) Action Research Arm Test (ARAT). (3) Stroke Impact Scale (SIS), indicating well-being, quality of life, emotion and social communication	No superior effects of either therapy on motor functions. Assessment of quality of life in the mobility domain in the SIS improved overall. Improvement of executive functions in the MST group support the beneficial effect of music making on cognitive flexibility

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27. Pfeiffer et al. (275-283) Social motor coordination during adult-child interactions Cat. 13: Attention, expectation Cat. 17: Sensorimotor	A feasibility study to explore social motor coordination (SMC) in dyads of an adult and a three-year old child during semi-structured social interactions	No musical material. Adult-child dyads performed a structured-play gaze-following task according to the Early Social Communication Scale (ESCS). CR: -	13 typically developing children interacted with an adult examiner in the semi-structured turn-taking task. Analysis of video-recorded movement was obtained by the frame-difference method (FDM)	To test the feasibility of the frame-difference method which measures differences in luminance of grayscale pixels between consecutive video frames	The study shows promise that the FDM and SMC pattern metrics could potentially offer a window to explore the nuances of SMC. Future work may include music interaction
28. Hambrick et al. (284-295) Toward a multifactorial model of expertise: beyond born versus made Cat. 8: Musicians Cat. 10: Training Cat. 22: Genomics	To discuss the "nature" view that expertise reflects "innate talent" versus the "nurture" view that differences in expertise reflect training history	No musical material. Critical discussion, documented by quotations of publications, of the claim that deliberate practice should explain most of the variance in expertise. CR: -	The authors have proposed a multifactorial gene-environment interaction model (MGIM) based on the assumption that expertise is multiply determined	To argue that the "nurture" view is inadequate to account for the evidence concerning the origins of expertise that has accumulated since the view was first proposed	The goal of expertise research should be to develop and test theories of expertise that take into account all potentially relevant explanatory constructs
29. Leo et al. (296-307) Sung melody enhances verbal learning and recall after stroke Cat. 5: Song Cat. 6: Language Cat. 11: Deficits Cat. 14: Memory	To investigate whether coupling novel verbal material with a musical melody can aid in its learning and recall in stroke patients with cognitive deficits	Sung-Spoken Story Recall Task (SSSRT): Four narrative stories, on average 57 words long, recorded by a female voice in (1) spoken format with natural prosody, and (2) in sung format on melodies composed to be simple. CR: Western	31 patients were tested at the acute stage (within 3 weeks of the stroke) and at the 6-months stage for memory deficits, aphasia and amusia, and tested by the SSSRT procedure: (1) Spoken task, three learning trials and a recall trial 25 min later. (2) Sung task, same protocol	Findings suggest that singing could be used as a mnemonic aid in the learning of novel verbal material in later stages of recovery after stroke	Memory performance on spoken and sung tasks did not differ at the acute stage, but sung stories were learned and recalled significantly better compared with spoken stories at the 6 months poststroke stage
30. Dalla Bella et al. (308-317) Individualization of music-based rhythmic auditory cueing in Parkinson's disease Cat. 4: Rhythm Cat. 11: Disorders Cat. 12: Therapy	To propose an individual approach to rhythmic auditory cueing in order to cope with the variable response in Parkinson's disease (PD) patients	Rhythmic stimuli were metronomes with a triangle timbre and computer-generated musical excerpts which had a salient beat structure, were pleasant, and conducive to movement. Examples: Mozart's Turkish March and highly familiar military marches. CR: Western	39 patients with PD and 39 matched controls were asked to walk together with the rhythmic stimuli. 22 patients showed a positive response to cueing, while 17 patients displayed a nonpositive response. Six patients showed significantly worsened gait performance in the presence of cues	Rhythmic cueing can be very beneficial for some patients, but deleterious for others. This calls for individualized rhythmic cueing	Individualized rhythmic cueing can be achieved via assistive mobile technologies compensating for rhythmic deficits by delivering cues that adapt in real time to patients' gait kinematics

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31. Grau-Sánchez et al. (318-328) Music-supported therapy in the rehabilitation of subacute stroke patients: a randomized controlled trial Cat. 11: Deficits Cat. 12: Rehabilitation Cat. 17: Sensorimotor Cat. 19: Mood, motivation	To conduct a Randomized Controlled Trial (RCT) in order to test the effectiveness of adding Music-supported therapy (MST) to a standard rehabilitation program in subacute stroke patients	MST group: Extra time for training the upper extremity with musical instruments. Conventional therapy (CT) group: Extra time for exercises for the upper extremity. CR: Western, W. popular	RCT: A group, n = 20, received 20 individual MST sessions. An active control group, n = 20, received 20 individual CT sessions. Pre- and post- tests of motor and cognitive functions, mood and quality of life. Follow-up test after 3 months	To provide equal conditions for both groups, offering supplementary treatment to the control group as well as to the MST group	MST as an add-on treatment showed no superiority to CT. Both groups significantly improved their motor deficits, and no differences between groups were found. MST enhanced patients' motivation to enjoy musical activities
32. Paquette et al. (329-337) Cross-classification of musical and vocal emotions in the auditory cortex Cat. 3: Complex sounds Cat. 6: Phonetic sounds Cat. 19: Emotion	To investigate whether emotions carried by voice and music are processed by the brain using similar mechanisms, employing multivoxel pattern analysis (MVPA) and machine learning classification	Short Musical Emotional Bursts (MEB) on violin or clarinet, expressing emotions: happiness, sadness, fear, neutral, and short Montreal Affective Voices (MAV) bursts portraying different emotions on the vowel "a". CR: -	fMRI acquisition of twenty participants while listening to 40 nonverbal emotional bursts (MAV), 40 clarinet and 40 violin musical emotional bursts (MEB). After scanning, emotion classification of the 120 stimuli	Inference is based on the ability of machine learning classifiers to classify emotions based on multivoxel pattern analysis (MVPA) of local fMRI patterns measured in response to the affective stimuli	The results provide evidence for a shared neural code for processing musical and vocal emotions in the auditory cortex
33. Bonacina et al. (338-348) Clapping in time parallels literacy and calls upon overlapping neural mechanisms in early readers Cat. 6: Language Cat. 17: Synchronization, sensorimotor	Using Interactive Metronome (IM), a technology requiring an individual to clap hands in time with a steady beat, to investigate potential links between literacy and synchronization skills in children who are learning to read	IM assesses synchronization ability by having a child clap in time with a pacing tone delivered over headphones. Synchronization was performed first without feedback, then with visual feedback on a computer screen. CR: -	In 64 children aged 5-7 years old, beat synchronization was assessed using IM. Furthermore, the children's auditory processing ability was assessed by measuring the subcortically evoked frequency-following response (FFR)	Hypothesis: The incorporation of feedback draws on phono-logical, cognitive, and auditory temporal skills engaging the sensory and motor systems important for reading, while only some of them are actively engaged in the no feedback condition	Results suggest that rhythm skills and literacy call on overlapping neural mechanisms, supporting the idea that rhythm training may boost literacy in part by engaging sensorimotor systems
34. Baylan et al. (349-359) Participants' experiences of music, mindful music, and audiobook listening interventions for people recovering from stroke Cat. 11: Deficits Cat. 12: Rehabilitation Cat. 13: Attention Cat. 14: Memory	To contribute to investigating the feasibility and acceptability of combining music listening and brief mindfulness training poststroke	An 8-week listening intervention, one hour daily: (1) self-selected music, or (2) A 5-min. mindfulness exercise followed by self-selected music, or (3) audiobooks based on participant's own preference. CR: Western, W. popular	58 participants with ischemic stroke were randomized to receive interventions (1), (2) or (3). Three-month postintervention: individual semi-structured qualitative interview	Themes emerging from interviews: positive impact on mood, relaxation, cognition (concentration, attentional control, memory reminiscence), increased activity	Across groups, positive distraction from worries. Mindful music listening was associated with relaxation, improved attention, and emotion regulation. Music listening was associated with increased activity, memory reminiscence, and improved mood

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35. Bugos (360-367) Protocol for a randomized controlled trial of piano training on cognitive and psychosocial outcomes Cat. 10: Training	To describe the protocol of a randomized controlled trial (RCT) to evaluate the effects of piano training on cognitive and psychosocial outcomes in healthy older adults	48 h of group training over 16 weeks. (1) Piano training: Piano technique, dexterity exercises, literature, music theory. (2) Computer training: Auditory intensive exercises, and "Card Shark" memory exercises. CR: Western	Groups of older adults, 60-80 years, n = approx. 30. (1) Group piano training, (2) Group computer brain training, (3) Control group. Tests: baseline, immediate posttest, and 3-month follow-up	To include an evidence-based control task – computer brain training – in addition to a no-treatment control group. Test analysis will compare changes in cognitive, psycho-social and neurophysiological outcomes	This research is the first to utilize piano training in the form of an RCT with a standardized group piano program. Statistical analysis is in progress
36. van Vugt and Ostry (368-377) From known to unknown: moving to unvisited locations in a novel sensorimotor map Cat. 13: Prediction Cat. 17: Sensorimotor	To investigate learning of a sensorimotor map which predicts relationships between movements and sensory effects, by exposing subjects to a novel mapping between arm movements and sounds	Sounds produced by three sine wave oscillators. One had a fixed frequency of 165 Hz. The frequencies of the other two decreased or increased linearly, in relation to the angle of the movement endpoint. CR: -	27 healthy participants. Learning novel sensorimotor maps was studied by letting subjects make arm movements to locations in space that each corresponded to a particular sound	Hypothesis to be tested: The learner linearly interpolates among discrete observations that are already in the map	Results suggest that interpolation happens to a limited extent only and that the acquisition of sensorimotor maps instead relies on a recombination of instance-based learning
37. Pearce (378-395) Statistical learning and probabilistic prediction in music cognition: mechanisms of stylistic enculturation Cat. 7: Cultural influence Cat. 13: Prediction, expectation	To review research that uses the computational Information Dynamics of Music (IDyOM) model of probabilistic prediction based on statistical learning to simulate data from empirical studies of music listeners	Music used in various studies: A chorale harmonized by J.S. Bach, Schubert's *Octet for Strings and Winds,* English hymns, Couperin's *Prélude non mesuré No.7,* German and Chinese folk songs. CR: Western, Chinese	Review of research that aims at predicting Western listeners' melodic pitch expectations in behavioral, physiological and EEG studies using a range of experimental paradigms	To examine whether the IDyOM model successfully can simulate the perception of mature, enculturated listeners, and can plausibly predict effects of differential cultural exposure to musical styles	Results show that processes involved in music perception – expectation, emotion, memory, similarity, segmentation, and meter – can be understood in terms of a single process of probabilistic prediction
38. Gámez et al. (396-414) Predictive rhythmic tapping to isochronous and tempo changing metronomes in the nonhuman primate Cat. 13: Prediction Cat. 17: Entrainment	To investigate whether monkeys share some human capabilities for rhythmic entrainment, such as tapping regularly at the period of isochronous stimuli, and entraining to dynamic tempo changes	Tasks: (1) tap in time with a sequence of brief visual or auditory stimuli with a constant interstimulus interval. (2) Monkeys only: same as (1), with tap-by-tap feedback. (3) tap in time with a sequence of visual stimuli that contained tempo changes. CR: -	Twenty humans, mean age 29 years. For task (1), 20 trials. For task (3), 60 trials. Three monkeys, age 9, 7, and 6 years, were initially trained with a visual metronome for 5 or 8 months. Performance measures during tasks: constant error, temporal variability, and asynchronies	To investigate whether monkeys can predictively entrain to dynamic tempo changes like humans	When immediate feedback about the timing of each movement is provided, monkeys can predictively entrain to an isochronous beat and to a novel untrained tempo. Monkeys exhibit a preference for visual metronomes and humans for auditory ones

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39. Bernardi et al. (415-426) Dancing to "groovy" music enhances the experience of flow Cat. 4: Groove Cat. 17: Entrainment Cat. 18: Bodily impact Cat. 19: Emotion, feeling	To test the potential effect of groove in mediating emotional responses during dance by including both high-groove and low-groove music excerpts	8 Music excerpts: Familiar and unfamiliar groovy music, familiar and unfamiliar non-groovy music plus white noise, edited to last 4 min.15 sec. In an online pilot survey, 40 participants rated each excerpt for groove on Likert scales. CR: Western, W. popular	40 participants were tested listening to groovy and non-groovy music while either dancing or standing. Also tested while imitating their own dance movements in the absence of music. Dance was recorded with motion capture. Emotion and flow ratings were collected after each condition	The experience of flow: a strongly rewarding experience of deep absorption and energized, focused attention. The dimension of groove: the degree to which a certain piece of music urges the listener to generate movements	The state of flow was increased specifically during spontaneous dance to groovy excerpts. Emotions in the realms of vitality (joy and power) and sublimity (wonder and nostalgia) were evoked by music in general, whether participants moved or not
40. Mosing and Ullén (427-434) Genetic influence on musical specialization: a twin study on choice of instrument and music genre Cat. 22: Genomics	To explore whether individual differences in instrument choice, instrument category, and type of music choice can be entirely explained by the environment or are partly due to genetic influences	Participants reported to play 45 different instruments, including song, choir and whistling. Participants indicated whether they had actively played (1) Art music, (2) jazz music, or (3) pop/rock or folk/world music. CR: Cross-cultural	1259 same-sex twin pairs reported to play an instrument or sing. Odds ratios were calculated for concordance in music choices, comparing identical and nonidentical twin pairs	Differences in concordance rate between 803 identical monozygotic (MZ), and 456 nonidentical dizygotic (DZ) same-sex twin pairs	Results indicated that identical twins are more likely to engage in the same type of music-related behavior than are nonidentical twins. The results suggest significant genetic influences on music specialization
41. Alain et al. (435-446) Different neural activities support auditory working memory in musicians and bilinguals Cat. 3: Complex sounds Cat. 6: Language Cat. 8: Musicians Cat. 14: Memory	To assess Working memory (WM) for spatial (sound location) and non-spatial (sound category) auditory information in (1) musician monolinguals (musicians), (2) non-musician bilinguals and (3) non-musician monolinguals (controls)	Stimuli: (a) meaningful human non-speech sounds, (e.g. coughing and laughing), (b) musical instruments (e.g. flute and clarinet), (c) meaningful environmental sounds (e.g. siren and water drop). Ten exemplars of each category, edited to durations of 1005 milliseconds. CR: Cross-cultural	41 young adults: 14 English-speaking musicians, 14 English-speaking non-musicians, 13 bilingual non-musicians. fMRI scans during listening to blocks of stimuli while performing WM tasks (spatial vs. non-spatial) and WM load tasks (1-back vs. 2-back)	To examine the recruitment of brain regions underlying executive control during auditory WM tasks in musicians and bilinguals. Focus on prefrontal and language-related areas	Musicians outperformed both groups of non-musicians on the WM task for sound category, but not on the spatial task. Findings suggest that musicians and bilinguals require less effort to successfully perform the WM tasks than controls