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## **Can rhythm-mediated reward boost learning, memory, and social connection? Perspectives for future research**

**Fiveash A<sup>1,2,3</sup>, Ferreri L<sup>4,5</sup>, Bouwer FL<sup>6</sup>, Kösem A<sup>1</sup>, Moghimi S<sup>7</sup>, Ravignani A<sup>8,9</sup>, Keller PE<sup>3,9</sup>, Tillmann B<sup>1,2,10</sup>**

1 Lyon Neuroscience Research Center, CRNL, CNRS, UMR 5292, INSERM U1028, F-69000 Lyon, France; 2 University of Lyon 1, Lyon, France; 3 The MARCS Institute for Brain, Behaviour and Development, Western Sydney University, Sydney, Australia; 4 Department of Brain and Behavioural Sciences, University of Pavia, Pavia, Italy; 5 Laboratoire d'Étude des Mécanismes Cognitifs, Université Lumière Lyon 2, Lyon, France; 6 Department of Psychology, Brain and Cognition, University of Amsterdam, Amsterdam, the Netherlands; 7 Groupe de Recherches sur l'Analyse Multimodale de la Fonction Cérébrale, INSERM U1105, Amiens, France; 8 Comparative Bioacoustics Group, Max Planck Institute for Psycholinguistics, 6525 XD Nijmegen, the Netherlands; 9 Center for Music in the Brain, Department of Clinical Medicine, Aarhus University & The Royal Academy of Music Aarhus/Aalborg, Denmark; 10 Laboratory for Research on Learning and Development, LEAD - CNRS UMR5022, Université de Bourgogne, Dijon, France.

[A.Fiveash@westernsydney.edu.au](mailto:A.Fiveash@westernsydney.edu.au)

Studies of rhythm processing and of reward have progressed separately, with little connection between the two. However, consistent links between rhythm and reward are beginning to surface, with research suggesting that synchronization to rhythm is rewarding, and that this rewarding element may in turn also boost this synchronization. The current mini review shows that the combined study of rhythm and reward can be beneficial to better understand their independent and combined roles across two central aspects of cognition: 1) learning and memory, and 2) social connection and interpersonal synchronization; which have so far been studied largely independently. From this basis, it is discussed how connections between rhythm and reward can be applied to learning and memory and social connection across different populations, taking into account individual differences, clinical populations, human development, and animal research. Future research will need to consider the rewarding nature of

rhythm, and that rhythm can in turn boost reward, potentially enhancing other cognitive and social processes.

*Gli studi sull'elaborazione del ritmo e sulla ricompensa sono progrediti separatamente, con poca connessione tra di loro. Tuttavia, stanno iniziando a emergere collegamenti coerenti tra ritmo e ricompensa, con la ricerca che suggerisce che la sincronizzazione con il ritmo è gratificante e che questo elemento gratificante possa a sua volta anche aumentare tale sincronizzazione. Questa mini revisione mostra che lo studio combinato del ritmo e della ricompensa può essere utile per comprendere meglio i loro ruoli indipendenti e combinati attraverso due aspetti centrali della cognizione: 1) apprendimento e memoria e 2) connessione sociale e sincronizzazione interpersonale, che finora sono stati studiati in gran parte in modo indipendente. Da questa base, viene discusso come le connessioni tra ritmo e ricompensa possano essere applicate all'apprendimento e alla memoria e alla connessione sociale tra diverse popolazioni, tenendo conto delle differenze individuali, delle popolazioni cliniche, dello sviluppo umano e della ricerca sugli animali. La ricerca futura dovrà considerare la natura gratificante del ritmo e che quel ritmo può a sua volta aumentare la ricompensa, migliorando potenzialmente altri processi cognitivi e sociali.*

[Health Care Women Int 2023 Apr](#)

## **The effects of listening to lullabies and self-selected music at home on prenatal stress and anxiety in nulliparous pregnant women: A randomized-controlled study**

[Baltacı N<sup>1</sup>, Doğan Yüksekol O<sup>2</sup>, Koç E<sup>3</sup>, Ulucan M<sup>2</sup>](#)

1 Department of Nursing, Faculty of Health Sciences, Ondokuz Mayıs University, Samsun, Turkey; 2 Department of Midwifery, Faculty of Health Sciences, Munzur University, Tunceli, Turkey; 3 Department of Midwifery, Faculty of Health Sciences, Ondokuz Mayıs University, Samsun, Turkey

To compare the effects of nulliparous pregnant women listening to lullabies and self-selected music on reducing the anxiety and antenatal stress. This was a randomized controlled study. Lullaby group (LG) (n = 40) listened to the lullaby chosen by the researcher, mixed music group (MG) (n = 40) listened to self-selected music and control group (CG) (n = 40) received general care. Post-test anxiety and stress levels was lower in two intervention groups versus CG ( $p < 0.01$ ). Post-test anxiety was lower in the MG versus LG ( $p < 0.01$ ), however post-test stress levels were similar. Pregnant women listening to self-selected music at home is more effective in reducing anxiety.

*Questo è stato uno studio controllato randomizzato per confrontare gli effetti dell'ascolto di ninne nanne e musica autoselezionata sulla riduzione dell'ansia e dello stress prenatale in donne incinte nullipare. Il gruppo ninna nanna (LG) (n = 40) ha ascoltato la ninna nanna scelta dal ricercatore, il gruppo musica mista (MG) (n = 40) ha ascoltato musica auto-selezionata e il gruppo di controllo (CG) (n = 40) ha ricevuto assistenza generale. I livelli di ansia e stress post-test erano inferiori nei due gruppi di intervento rispetto a CG ( $p < 0,01$ ). L'ansia post-test era inferiore nel MG rispetto a LG ( $p < 0,01$ ), tuttavia i livelli di stress post-test erano simili. La condizione di musica scelta a casa dalle donne incinte era la più efficace nel ridurre l'ansia.*

[Interface Focus 2023 Apr 14; 13](#)

## **The lack of temporal brain dynamics asymmetry as a signature of impaired consciousness states**

[G-Guzmán E<sup>1</sup>, Sanz Perl Y<sup>1,2</sup>, Vohryzek J<sup>1,3</sup>, Escrichs A<sup>1</sup>, Manasova D<sup>2,4</sup>, Türker B<sup>2</sup>, Tagliazucchi E<sup>5,6</sup>, Kringelbach M<sup>3,7</sup>, Sitt JD<sup>2</sup>, Deco G<sup>1,8,9,10</sup>](#)

1 Department of Information and Communication Technologies, Centre for Brain and Cognition, Computational Neuroscience Group, Universitat Pompeu Fabra, Barcelona, Spain; 2 Sorbonne Université, Institut du Cerveau - Paris Brain Institute - ICM, Inserm Physiological Investigation of Clinically Normal and Impaired Cognition Team, CNRS, 75013, Paris, France; 3 Centre for Eudaimonia and Human Flourishing, Linacre College, University of Oxford, Oxford, UK; 4 Université Paris Cité, Paris, France; 5 Buenos Aires Physics Institute and Physics Department, University of Buenos Aires, Buenos Aires, Argentina; 6 Latin American Brain Health (BrainLat), Universidad Adolfo Ibáñez, Santiago, Chile; 7 Department of Clinical Medicine, Center for Music in the Brain, Aarhus University, Jutland, Denmark; 8 Institució Catalana de la Recerca i Estudis Avançats (ICREA), Barcelona, Catalonia, Spain; 9 Department of Neuropsychology, Max Planck Institute for human Cognitive and Brain Sciences, Leipzig, Germany; 10 School of Psychological Sciences, Monash University, Melbourne, Australia

Life is a constant battle against equilibrium. From the cellular level to the macroscopic scale, living organisms as dissipative systems require the violation of their detailed balance, i.e. metabolic enzymatic reactions, in order to survive. We present a framework based on temporal asymmetry as a measure of non-equilibrium. By means of statistical physics, it was discovered that temporal asymmetries establish an arrow of time useful for assessing the reversibility in human brain time series. Previous studies in human and non-human primates have shown that decreased consciousness states such as sleep and anaesthesia result in brain dynamics closer to the equilibrium. Furthermore, there is growing interest in the analysis of brain symmetry based on neuroimaging recordings and since it is a non-invasive technique, it can be extended to different brain imaging modalities and applied at different temporal-spatial scales. In the present study, we provide a detailed description of our methodological approach, paying special attention to the theories that motivated this work. We test, for the first time, the reversibility analysis in human functional magnetic resonance imaging data in patients suffering from disorder of consciousness. We verify that the tendency of a decrease in the asymmetry of the brain signal together with the decrease in non-stationarity are key characteristics of impaired consciousness states. We expect that this work will open the way for assessing biomarkers for patients' improvement and classification, as well as motivating further research on the mechanistic understanding underlying states of impaired consciousness.

*La vita è una costante lotta contro l'equilibrio. Dal livello cellulare alla scala macroscopica, gli organismi viventi, in quanto sistemi dissipativi, per sopravvivere necessitano della violazione del loro equilibrio nel dettaglio, cioè delle reazioni metaboliche enzimatiche. Gli Autori presentano un quadro di riferimento basato sull'asimmetria temporale come misura del non-equilibrio. Attraverso la fisica statistica, si è scoperto che le asimmetrie temporali stabiliscono una freccia del tempo utile per valutare la reversibilità nelle serie temporali del cervello umano. Studi precedenti su primati umani e non umani hanno dimostrato che gli stati di coscienza ridotta, come il sonno e l'anestesia, determinano dinamiche cerebrali più vicine all'equilibrio. Inoltre, vi è un crescente interesse per l'analisi della simmetria cerebrale basata su registrazioni di neuroimmagini e, poiché si tratta di una tecnica non invasiva, può essere estesa a diverse modalità di imaging cerebrale e applicata a diverse scale temporo-spaziali. Nello studio, viene fornita una descrizione dettagliata di questo approccio metodologico, prestando particolare attenzione alle teorie che hanno motivato tale lavoro. Si testa, per la prima volta, l'analisi della reversibilità nei dati di risonanza magnetica funzionale umana in pazienti affetti da disturbi della coscienza. Si verifica che la tendenza alla diminuzione dell'asimmetria del segnale cerebrale e la diminuzione della non stazionarietà sono caratteristiche fondamentali degli stati di coscienza compromessi. Gli Autori si aspettano che questo lavoro apra la strada alla valutazione di biomarcatori per il miglioramento e la classificazione dei pazienti, oltre a motivare ulteriori ricerche sulla comprensione meccanicistica alla base degli stati di alterazione della coscienza.*

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**The human language system, including its inferior frontal component in "Broca's area," does not support music perception**

**Chen X<sup>1,2,3</sup>, Affourtit J<sup>2,3</sup>, Ryskin R<sup>2,3,4</sup>, Regev TI<sup>2,3</sup>, Norman-Haignere S<sup>5,6,7,8</sup>, Jouravlev O<sup>2,3,9</sup>, Malik-Moraleda S<sup>2,3,10</sup>, Kean H<sup>2,3</sup>, Varley R<sup>11</sup>, Fedorenko E<sup>2,3,10</sup>**

1 Department of Cognitive Sciences, Rice University, TX 77005, USA; 2 Department of Brain and Cognitive Sciences, MIT, Cambridge, MA 02139, USA; 3 McGovern Institute for Brain Research, MIT, Cambridge, MA 02139, USA; 4 Department of Cognitive & Information Sciences, University of California, Merced, Merced, CA 95343, USA; 5 Department of Biostatistics & Computational Biology, University of Rochester Medical Center, Rochester, NY, USA; 6 Department of Neuroscience, University of Rochester Medical Center, Rochester, NY, USA; 7 Department of Biomedical Engineering, University of Rochester, Rochester, NY, USA; 8 Department of Brain and Cognitive Sciences, University of Rochester, Rochester, NY, USA; 9 Department of Cognitive Science, Carleton University, Ottawa, ON, Canada; 10 The Program in Speech and Hearing Bioscience and Technology, Harvard University, Cambridge, MA 02138, USA; 11 Psychology & Language Sciences, UCL, London, WCN1 1PF, UK

Language and music are two human-unique capacities whose relationship remains debated. Some have argued for overlap in processing mechanisms, especially for structure processing. Such claims often concern the inferior frontal component of the language system located within "Broca's area." However, others have failed to find overlap. Using a robust individual-subject fMRI approach, we examined the responses of language brain regions to music stimuli, and probed the musical abilities of individuals with severe aphasia. Across 4 experiments, we obtained a clear answer: music perception does not engage the language system, and judgments about music structure are possible even in the presence of severe damage to the language network. In particular, the language regions' responses to music are generally low, often below the fixation baseline, and never exceed responses elicited by nonmusic auditory conditions, like animal sounds. Furthermore, the language regions are not sensitive to music structure: they show low responses to both intact and structure-scrambled music, and to melodies with vs. without structural violations. Finally, in line with past patient investigations, individuals with aphasia, who cannot judge sentence grammaticality, perform well on melody well-formedness judgments. Thus, the mechanisms that process structure in language do not appear to process music, including music syntax.

*La lingua e la musica sono due capacità umane uniche il cui rapporto rimane dibattuto. Alcuni hanno sostenuto la sovrapposizione nei meccanismi di elaborazione, in particolare per l'elaborazione della struttura. Tali affermazioni riguardano spesso la componente frontale inferiore del sistema linguistico situata all'interno dell'"area di Broca". Tuttavia, altri non sono riusciti a trovare sovrapposizioni. Utilizzando un robusto approccio fMRI individuo-soggetto, gli Autori hanno esaminato le risposte delle regioni del cervello del linguaggio agli stimoli musicali e sondato le capacità musicali degli individui con grave afasia. Attraverso 4 esperimenti, è stata ottenuta una risposta chiara: la percezione musicale non coinvolge il sistema linguistico e sono possibili giudizi sulla struttura musicale anche in presenza di gravi danni alla rete linguistica. In particolare, le risposte delle regioni linguistiche alla musica sono generalmente basse, spesso al di sotto della linea di base della fissazione, e non superano mai le risposte suscitate da condizioni uditive diverse dalla musica, come i versi degli animali. Inoltre, le regioni linguistiche non sono sensibili alla struttura musicale: mostrano risposte basse sia alla musica intatta che a quella con struttura criptata, e alle melodie con o senza violazioni strutturali. Infine, in linea con le precedenti indagini sui pazienti, gli individui con afasia, che non possono giudicare la grammaticità della frase, si comportano bene nei giudizi sulla buona formazione della melodia. Pertanto, i meccanismi che elaborano la struttura nel linguaggio non sembrano elaborare la musica, inclusa la sintassi musicale.*

#### **The Pierfranco and Luisa Mariani Foundation**

*Since its beginnings in 1985, the Mariani Foundation has established itself as a leading organization in the field of paediatric neurology by organizing a variety of advanced courses, providing research grants, and supporting specialized care. The Foundation works in close cooperation with major public healthcare institutions, complementing their scientific programs and other activities. In 2009 it became the first private entity in Italy to join the founding members of the National Neurologic Institute "Carlo Besta" in Milan. In addition to its services, the Foundation aims, through its continuing medical education courses and publications, to spread knowledge in the field of paediatric neurology in order to help treat or alleviate a large number of paediatric neurologic disorders.*

*In the year 2000, the Mariani Foundation has added a new and important dimension to its activities: fostering the study of the multiple links between the neurosciences and music, including music education and early intervention. This significant commitment has inspired the series of "Neurosciences and Music" conferences, held in Venice (2002), Leipzig (2005), Montreal (2008), Edinburgh (2011), Dijon (2014), Boston (2017), and Aarhus (2021). All these meetings have led to the publication of major volumes in the Annals of the New York Academy of Sciences.*

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Editorial coordinator: Renata Brizzi

For further information: [neuromusic@fondazione-mariani.org](mailto:neuromusic@fondazione-mariani.org)

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