The ability to discriminate phonemes varying in spectral and temporal attributes constitutes one of the most basic intrinsic elements underlying language learning mechanisms. Since previous work has consistently shown that professional musicians are characterized by perceptual and cognitive advantages in a variety of language-related tasks, and since vowels can be considered musical sounds within the domain of speech, here we investigated the behavioral and electrophysiological correlates of native vowel discrimination learning in a sample of professional musicians and non-musicians. We evaluated the contribution of both the neurophysiological underpinnings of perceptual (i.e., N1/P2 complex) and mnemonic functions (i.e., N400 and P600 responses) while the participants were instructed to judge whether pairs of native consonant-vowel (CV) syllables manipulated in the first formant transition of the vowel (i.e., from /tu/ to /to/) were identical or not. Results clearly demonstrated faster learning in musicians, compared to non-musicians, as reflected by shorter reaction times and higher accuracy. Most notably, in terms of morphology, time course, and voltage strength, this steeper learning curve was accompanied by distinctive N400 and P600 manifestations between the two groups. In contrast, we did not reveal any group differences during the early stages of auditory processing (i.e., N1/P2 complex), suggesting that faster learning was mediated by an optimization of mnemonic but not perceptual functions. Based on a clear taxonomy of the mnemonic functions involved in the task, results are interpreted as pointing to a relationship between faster learning mechanisms in musicians and an optimization of echoic (i.e., N400 component) and working memory (i.e., P600 component) functions.
La capacità di discriminare fonemi che variano nelle caratteristiche degli attributi è uno degli elementi di base che caratterizzano i meccanismi di acquisizione del linguaggio. Dal momento che studi precedenti hanno dimostrato che i musicisti presentano un vantaggio percettivo e cognitivo in una vasta gamma di esercizi che coinvolgono il linguaggio, e dato che le vocali possono essere considerate suoni musicali nell’ambito del linguaggio, gli Autori hanno voluto investigare i correlati neurali della capacità di discriminare le vocali in una lingua nativa da parte di musicisti e non musicisti. Gli Autori hanno valutato il contributo dei fattori percettivi (complesso N1/P2) e mnemonici (riposta P400 e P600) durante un esercizio in cui i partecipanti dovevano giudicare se alcune coppie di sillabe consonante-vocale (CV) native, manipolate nella prima transizione della formante della vocale (ad esempio da tu a to etc.), fossero identiche o no. I risultati mostrano chiaramente una capacità di apprendimento più veloce nei musicisti, che si riflette in una maggiore rapidità e accuratezza. Particolarmente importante il fatto che in termini di morfologia, tempistica e intensità di voltaggio, questa curva più rapida si accompagnava a diverse risposte di N400 e P600 tra i due gruppi. Al contrario, gli Autori non hanno rilevato alcuna differenza sostanziale nei primi stadi dell’elaborazione uditiva (N1/P2), suggerendo che l’apprendimento sia mediato dal miglioramento dei processi mnemonici ma non percettivi. Basandosi sulla chiara tassonomia delle funzioni mnemoniche, gli Autori concludono che questa maggiore capacità di apprendimento dei musicisti sia mediata da una ottimizzazione delle funzioni di memoria eoca (i.e. componente N400) e di lavoro (i.e. componente P600).

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Statistical learning of melodic patterns influences the brain's response to wrong notes

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The theory of statistical learning has been influential in providing a framework for how humans learn to segment patterns of regularities from continuous sensory inputs, such as speech and music. This form of learning is based on statistical cues and is thought to underlie the ability to learn to segment patterns of regularities from continuous sensory inputs, such as the transition probabilities in speech and music. However, the connection between statistical learning and brain measurements is not well understood. Here we focus on ERPs in the context of tone sequences that contain statistically cohesive melodic patterns. We hypothesized that implicit learning of statistical regularities would influence what was held in auditory working memory. We predicted that a wrong note occurring within a cohesive pattern (within-pattern deviant) would lead to a significantly larger brain signal than a wrong note occurring between cohesive patterns (between-pattern deviant), even though both deviant types were equally likely to occur with respect to the global tone sequence. We discuss this prediction within a simple Markov model framework that learns the transition probability regularities within the tone sequence. Results show that signal strength was stronger when cohesive patterns were violated and demonstrate that the transitional probability of the sequence influences the memory basis for melodic patterns. Our results thus characterize how informational units are stored in auditory memory trace for deviance detection and provide new evidence about how the brain organizes sequential sound input that is useful for perception.

La teoria dell’apprendimento statistico è stata di grande aiuto nell’elaborazione di una teoria dell’apprendimento del linguaggio negli esseri umani e si basa sulla capacità di segmentare pattern ripetuti all’interno di suoni continui, come le probabilità di transizione nella musica e nel linguaggio. D’altra parte, la connessione tra apprendimento statistico e misure neurofisiologiche non è ancora stata compresa a fondo. In questo studio gli Autori si focalizzano sui potenziali evocati nel contesto di sequenze di toni che contengono pattern melodici statisticamente coesivi. Gli Autori ipotizzano che l’apprendimento implicito delle regolarità statistiche influenzi quello che viene trattenuto nella memoria di lavoro. Gli Autori prevedono che una nota sbagliata che viene inserita all’interno di un pattern coesivo (deviante entro il pattern) possa determinare un segnale cerebrale più ampio di quanto non faccia una nota sbagliata che viene inserita tra un pattern coesivo e l’altro (deviante fra pattern), sebbene entrambe le varianti abbiano la stessa probabilità rispetto alla sequenza globale dei toni. Gli
Direct electrical stimulation in the human brain disrupts melody processing

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Prior research using functional magnetic resonance imaging (fMRI) [1-4] and behavioral studies of patients with acquired or congenital amusia [5-8] suggest that the right posterior superior temporal gyrus (STG) in the human brain is specialized for aspects of music processing (for review, see [9-12]). Intracranial electrical brain stimulation in awake neurosurgery patients is a powerful means to determine the computations supported by specific brain regions and networks [13-21] because it provides reversible causal evidence with high spatial resolution (for review, see [22, 23]). Prior intracranial stimulation or cortical cooling studies have investigated musical abilities related to reading music scores [13, 14] and singing familiar songs [24, 25]. However, individuals with amusia (congenitally, or from a brain injury) have difficulty humming melodies but can be spared for singing familiar songs with familiar lyrics [26]. Here we report a detailed study of a musician with a low-grade tumor in the right temporal lobe. Functional MRI was used pre-operatively to localize music processing to the right STG, and the patient subsequently underwent awake intraoperative mapping using direct electrical stimulation during a melody repetition task. Stimulation of the right STG induced “music arrest” and errors in pitch but did not affect language processing. These findings provide causal evidence for the functional segregation of music and language processing in the human brain and confirm a specific role of the right STG in melody processing.
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Musical training modulates the early but not the late stage of rhythmic syntactic processing
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Syntactic processing is essential for musical understanding. Although the processing of harmonic syntax has been well studied, very little is known about the neural mechanisms underlying rhythmic syntactic processing. The present study investigated the neural processing of rhythmic syntax and whether and to what extent long-term musical training impacts such processing. Fourteen musicians and 14 nonmusicians listened to syntactic-regular or syntactic-irregular rhythmic sequences and judged the completeness of these sequences. Nonmusicians, as well as musicians, showed a P600 effect to syntactic-irregular endings, indicating that musical exposure and perceptual learning of music are sufficient to enable nonmusicians to process rhythmic syntax at the late stage. However, musicians, but not nonmusicians, also exhibited an early right anterior negativity (ERAN) response to syntactic-irregular endings, which suggests that musical training only modulates the early but not the late stage of rhythmic syntactic processing. These findings revealed for the first time the neural mechanisms underlying the processing of rhythmic syntax in music, which has important implications for theories of hierarchically organized music cognition and comparative studies of syntactic processing in music and language.

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In 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. The results of this commitment are shown first and foremost in "The Neurosciences and Music" conferences, held in Venice (2002), Leipzig (2005), Montreal (2008), Edinburgh (2011), and Dijon (2014). The last congress was held in June 2017 in Boston, in partnership with the Harvard Medical School and Beth Israel Deaconess Medical Center. All these meetings have led to the publication of major volumes in the Annals of the New York Academy of Sciences. By providing the most recent information in these rapidly advancing neurologic fields, the Mariani Foundation intends to be a reliable and informative source for specialists and journalists in this new area of the developmental neurosciences.

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