Fondazione
Pierfranco e Luisa Mariani
ONLUS
neurologia infantile

Neuromusic News

N°12 - 14.06.2007

Special Issue on the International Workshop on the Biology and Genetics of Music
Bologna, 20-22 may

This special issue is dedicated to selection of abstracts relating to the specific field of interest of the Mariani Foundation, in the Neuroscience and Music Project.

Structural and functional features of human auditory-related cortex: Possible clues in the search for genetic links

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A prerequisite for establishing links between genes and musical behaviors is to characterize the neural substrates underlying such behaviors. This presentation will summarize some of the crucial functional and anatomical specializations of the human brain that may be relevant. In particular, we will emphasize studies of two important music-related abilities: pitch and rhythm. The neural substrates of pitch perception are particularly relevant, as they reveal certain specializations in auditory cortex; processing of absolute pitch may offer a particularly useful model for revealing the interaction between genetic, environmental, and maturational factors. A second area of research that may be fruitful to consider involves rhythmic motor reproduction; current evidence for auditory-motor interactions revealed by such studies may prove important in terms of potential linkages. Finally, we will consider whether any data support the contention that pre-existing anatomical or functional neural features may predispose individuals to success with musical training.

Uno studio effettuato attraverso la risonanza magnetica ha valutato possibili differenze anatomiche nelle varie regioni cerebrali coinvolte nel processamento della musica, tra musicisti e non musicisti. I risultati hanno rilevato nei musicisti una differenza nello spessore di alcune aree cerebrali come la corteccia temporale e parietale destra, e l'area ippocampale. Affascinante è stata la scoperta che l'ispessimento corticale si riscontra anche nella corteccia frontale. Da questo studio possono emergere legami importanti fra le aree cerebrali coinvolte nell'integrazione uditivo-motoria.

Explaining exceptionally high and exceptionally low achievement in music: elite performers, savants, and the self-defined "tone deaf"

John Sloboda
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Convincing explanations for high levels of musical achievement can be provided through research studies on non-genetic factors, such as practice, motivation, and social support. This is true even for abnormal groups such as musical savants. It follows that low musical achievement is very often caused by absence of these environmental factors, rather than any inherited deficit. But, many people with low musical achievement believe they have some inherent deficit. They talk of themselves as "unmusical" or "tone deaf". While it is the case that a small percentage of people (maybe 4-5%) have a dense perceptual specific musical deficit (labelled as "congenital amusia" by Peretz and colleagues), up to 15% of college-aged populations self-define as "tone deaf". This talk reports on a research programme which is mapping the deficit profile of different groups of people, all of whom share objectively low levels of musical achievement. The research is demonstrating that many people who self-define as tone-deaf have perceptual skills indistinguishable from normals, and that the key deficits appear to be in the area of planning and monitoring of singing behaviour. Furthermore, these deficits are highly context specific, and often respond to very modest interventions, for example, the provision of accompaniment. The research adds to the growing evidence to support the conclusion that the musical capacity needed for expert musical achievement is probably shared by the great majority of the population, and that only the very extreme reaches of high or low achievement are to be accounted for primarily in terms of genetic differences.

Sloboda suggerisce che la maggior parte della popolazione umana abbia doti musicali innate. Le differenze riscontrabili nelle abilità musicali sembrano correlati più a fattori culturali, ambientali e di mancato esercizio musicale, soprattutto nel canto, che non a fattori genetici o biologici in genere. Sorprendente è riscontrare nella popolazione media un folto gruppo di persone che considerano se stesse come stonate, una condizione che sappiamo essere rara in natura, dato che l'amusia congenita colpisce circa il 4% della popolazione. Tutti possono raggiungere un discreto livello musicale con un pò d'esercizio e una buona motivazione

Probing the Evolutionary Origins of Music Perception

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From the perspective of cognitive science, music ranks among the most bizarre features of human experience. Music is apparently universal, playing a prominent role in every known culture, past and present, and humans everywhere expend vast resources and time producing and listening to music. But despite its central position in human culture, the origins and adaptive function of music remain virtually a complete mystery - unlike most other enjoyable human behaviors, music yields no obvious benefit to those who partake of it. Music has thus puzzled evolutionary theorists since the time of Darwin. In this talk I will discuss my recent efforts to provide empirical constraints on the origins of music.

We claim that theories of the origins of music will be usefully constrained if we can determine which aspects of music perception are innate, and of those which are uniquely human and specific to music. Comparative research in nonhuman animals, particularly nonhuman primates, is thus critical to the debate. We have focused on the preferences that characterize most humans? experience of music, testing for whether similar preferences exist in nonhuman primates. One series of studies in nonhuman primates explored whether they have
sound preferences that might be related to music perception in humans. These experiments have revealed preferences in monkeys that are markedly different from those found in humans - monkeys seem to lack a preference for consonance over dissonance, and generally appear to find musical stimuli aversive, choosing to listen to silence over music when given the choice. A second set of
studies examined whether preferences for music can be instantiated in nonhuman primates with exposure to music. We find that exposure can indeed induce preferences if it occurs when the animals are young, but

that the preferences induced are quite specific to the stimuli used. Such "mere" exposure effects thus seem unlikely to account for the preferences found in humans. Our results are consistent with the notion that many rudimentary acoustic
preferences, such as that for consonant over dissonant intervals, are unique to humans. If these preferences prove to be innate in humans, they may be candidates for music-specific adaptations.

L'essere umano è l'unico che apprezza la musica tra i primati. Gli studi sulle scimmie e su specie evolutivamente più distanti come i cani hanno dimostrato che gli animali non amino la musica né apprezzino l'armonia dei suoni. Per loro il cigolio di una porta o la sonata di Mozart hanno lo stesso valore e preferiscono in assoluto il silenzio. Anche dopo un periodo di training in cui l'autore ha cercato di fornire ai cuccioli di scimmia una certa competenza musicale il risultato non cambia e suggerisce che l'evoluzione della preferenza musicale sia un fatto esclusivamente umano e potrebbe essere un esempio di adattamento specifico per la musica.

Genetics and phenotypes in tune-deafness

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Deficits in musical pitch perception have been shown to be strongly genetic in origin.
We have evaluated a group of families ascertained via tune-deaf probands, and measured musical pitch recognition in family members. Our results demonstrate that deficits in musical pitch perception frequently occur in relatives of probands, but that relatives display a wide spectrum of severity, and that Mendelian segregation of complete tune-deafness typically does not occur. This suggests that tune-deafness can be classified as a complex trait.

To address the challenges of gene identification for complex traits, we have performed a detailed phenotypic evaluation of a large sample of randomly ascertained tune-deaf individuals. We measured attention with the Test of Variables of Attention (TOVA), and found that attention deficit, another trait with strong genetic contributions, is a common source of poor performance on auditory tests.

We have confirmed and extended previous findings that indicate tune-deaf subjects have normal memory, but can display deficits in auditory temporal recognition. Measurement of difference limen for frequency shows that approximately one third of tune-deaf subjects display normal ability to discriminate pure tones at 1000 Hz. We have also found that tune-deaf subjects also display a range of deficits in recognition of non-musical sounds, particularly speech sounds. This additional phenotype information will be important in future genetic studies of tune-deafness.

L'amusia sembra in gran parte determinata da fattori genetici, ma l'analisi di un ampio gruppo familiare con individui amusici a vari livelli ha dimostrato che non esiste una segregazione mendeliana completa, ovvero che non sia identificabile un gene preciso che determini questo tratto, ma che l'amusia sia piuttosto da considerarsi un quadro molto complesso al quale contribuiscono molti fattori. Gli autori hanno anche rilevato che il deficit di attenzione è una caratteristica molto comune degli individui amusici che possono presentare difficoltà anche nel riconoscimento di suoni non musicali come il linguaggio.

Evolution and natural meaning in music

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University of Cambridge

Music is often viewed as a pleasant though insignificant aspect of present-day life. But research has shown that music is central to life in many pre-modern societies, and that music, or activities that have focal musical features, are an integral part of early mother-infant interactions. Indeed, research indicates that music is far more significant in the lives of most members of contemporary society than is generally believed. I shall draw on ethnomusicological and psychological studies of music to propose that music is in fact a fundamental component of the human communicative toolkit, powerfully complementing language in constituting a medium that is optimally suited to the management of social uncertainty.I shall outline an operational definition of music as a mode of social interaction in terms of its generic, cross-cultural properties that facilitates comparison with language as a universal human faculty. I shall argue that, despite the fact that music appears much more heterogeneous and differentiated in function from culture to culture than does language, music possesses common attributes across cultures: it exploits the human capacity to entrain to external (particularly social) stimuli, and presents a rich set of semantic fields while under-determining meaning.
I shall suggest that music's capacity to bear meaning has deep evolutionary roots, deriving from both species-general sensitivities linking features of the auditory environment and biological significance, and from species-specific sensitivities to the types of sonic and gestural performative cues that are manifested in human social interaction. To these two dimensions of musical meaning must be added a third, deriving from the particularities of the cultural contexts in which we develop and that we enact. These three dimensions of meaning in the experience of music endow it with a semantic open-ness that, together with its capacity to structure time so as to create a sense of shared action, allows it to function as a communicative medium that is highly adapted to situations of social uncertainty. I shall draw on evolutionary and archaeological evidence to suggest that a faculty for music is likely to have been exaptive in the evolution of the human capacity for complex social interaction in providing a medium by means of which a capacity for flexible social interaction is likely to have been explored and reinforced.

Partendo dal concetto che la musica è una prerogativa umana, Cross indaga sul possibile significato delle abilità musicali. Il suo studio conclude che la musica ha permesso interazioni sociali complesse tra gli esseri umani. La capacità della musica di generare emozioni nell'uomo e di arricchire il linguaggio è certamente comparsa con la musica stessa e potrebbe aver avuto un significato profondo durante l'evoluzione integrando e facilitando l'uso delle comunicazioni verbali.

The Genetics of Congenital Amusia (or tone-deafness): Family Aggregation

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Congenital amusia (commonly known as tone-deafness) is a lifelong impairment of music perception and memory that affects 4 % of the population. To estimate if congenital amusia can be genetically transmitted, its prevalence was quantified by direct auditory testing in 10 large families of amusic probands and in 10 control families. The results confirm that congenital amusia is expressed by a deficit in processing musical pitch and not musical time, and further show that the pitch disorder has a strong hereditary component. In amusic families, 40% of first-degree relatives have the same cognitive disorder whereas only 3% have it in the control families. The high sibling relative risk λ_s of 10.8 (95% CI 8-13.5) found in multiplex families will enable the mapping of genetic loci for hereditary amusia.

Lo studio conferma le forti determinanti genetiche alla base dell'amusia. Studiando 10 grandi famiglie di amusici è stato possibile stabilire che ben il 40% dei discendenti di primo grado ereditano questo difetto mentre nelle famiglie di controllo l'amusia si presenta nel 3% dei casi.

Absolute Pitch: Genetics and Perception

Jane Gitschier, Alexandra Athos, Barbara Levinson, Alan Bostrom, Nelson Freimer, Elizabeth Theusch, Jason Zemansky, and Amy Kistler
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Absolute pitch (AP), often referred to as perfect pitch, is the rare ability to identify the pitch of a tone without the aid of a reference tone. This perceptual gift is distinguishable from relative pitch, a learned skill common in trained musicians, in which a pitch is rapidly derived by its interval from a reference pitch. The genesis of AP has been of interest to musicians, psychologists and neuroscientists, with recent studies supporting inborn anatomical and genetic, rather than experiential, underpinnings. We employed a Web-based survey and pitch-labeling test to recruit subjects with AP into our study on the genetic basis of absolute pitch. Here, we examine the wealth of perceptual data emanating from 981 individuals who meet our stringent criteria for AP. Our analysis revealed three striking phenomena: an age-dependent perceptual distortion of pitch in the sharp direction; note-naming irregularities suggestive of a perceptual magnet centered at the musical note "A"; and a bimodal distribution of pitch-naming ability, possibly implicating the influence of one or a few genes with large effects on this complex trait. These findings show that AP subjects offer a unique window into flexibility in auditory architecture and augur well for unraveling its genetic contribution.

Questo gruppo ha selezionato individui con orecchio assoluto attraverso un test disponibile sul web. Lo studio di 981 individui così selezionati, ha permesso di notare tre fenomeni: Una distorsione percettiva dipendente dall'età che tendeva ad attribuire alle note valori tendenti al "diesis". Alcune irregolarità nell'etichettare correttamente le note, soprattutto intorno alle ferequenze del La, definito dagli autori "magnete percettivo" e una distribuzione bimodale della capacità di etichettare i toni, che potrebbe indicare l'influenza di uno o più geni con ampio effetto su questo tratto complesso.

Could a congenital disorder of musical perception ever be explained by a single gene? Relating neuronal organization to a complex behavioural phenotype

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Our work addresses whether amusia might be adequately defined by generic deficits in the analysis of complex sound, and the brain basis for these. Previous work demonstrating a deficit in the analysis of pitch direction in subjects with amusia (Foxton *et al*., 2004) has been replicated in a distinct cohort of ten subjects with severe amusia using a three-interval-forced-choice 'odd-one-out' paradigm that is much easier for naïve subjects. Group inference shows significant deficits in pitch-direction analysis in the amusia group compared to a group of matched controls: the deficit can be striking in individual amusic subjects. Ongoing work is testing the hypothesis that there is a key underlying deficit
in working memory for pitch.

Pitch-direction analysis is likely to depend on a right-lateralized network including the secondary auditory cortices and inferior frontal cortex (Stewart *et al*., 2006). Recent voxel-based-morphometry data acquired in collaboration with the Montreal group (Hyde *et al*., 2006) demonstrate either an increase in grey-matter density or a decrease in white-matter density in right inferior frontal cortex. In either event, such deficits could be produced by single genes. An increase in grey-matter density could be caused by heterotopic cortex due to a neuronal migration disorder (which can be due to an autosomal dominant or x-linked recessive single-gene disorder). A decrease in white-matter density might reflect a disorder of axonal guidance which could be plausibly related to a single gene such as that for a cell-adhesion molecule.

We have recently identified a multiply affected amusia family with a pattern of inheritance consistent with an autosomal dominant disorder with high penetrance. Ongoing work is being carried out to characterize the phenotype and genotype. It will be of considerable future interest to determine the extent to which amusia might be explained by single genes, or whether it might be explained by rare single genes and a more common polygenic predisposition (like dementia or schizophrenia).

Questo studio suggerisce la possibilità che l'amusia possa essere ereditata come malattia trasmessa da un singolo gene. L'analisi morfometrica dei soggetti amusici ha evidenziato alcune alterazioni che, secondo gli autori, potrebbero essere relative a mutazioni di un singolo gene e che influenzano le strutture anatomiche coinvolte nel processamento dei suoni, in particolare nella corteccia infero-frontale destra Gli autori hanno anche identificato una famiglia in cui l'amusia era ereditata come tratto autosomico dominante.

The Pierfranco and Luisa Mariani Foundation ONLUS

During its twenty years of activity, by organizing a variety of advanced courses, providing research grants, and supporting specialized services, the Mariani Foundation has established itself as a leading organization in the field of paediatric neurology.
The Foundation works in close co-operation with leading public health care institutions, playing a complementary role to theirs.
Besides its institutional purposes, the Foundation has elected an additional mission: communicating the latest discoveries in the area, contributing to the spread of knowledge in the struggle against paediatric neurological diseases.

*In the latest years the Mariani Foundation has added a new important goal to the roster of its activities in training and research: stimulating the investigations on the multiple links between "**The Neurosciences and Music"**. The positive results of this commitment have been highlighted in the success of the two conferences held in Venice (2002) and in Leipzig (2005). Both meetings have led to the publication of major volumes on the subject, in the prestigious series "Annals of the New York Academy of Sciences". In addition, the Mariani Foundation is constantly involved in other events on this topic, such as the next congress planned for 2008 in Montreal, where the internationally renowned "BRAMS" group is already active and influential. Currently, activities of information and promotion are strengthened through this newsletter and in the project of a website entirely dedicated to "Neuromusic". Thereby, the Mariani Foundation intends to develop as an international reference source for journalists and scientists operating in this new area of the neurosciences*.

Neuromusic News edited by InSintesi for Fondazione Mariani.
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