

# Chapter 1

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## The Evolutionary Basis of Meaning in Music: Some Neurological and Neuroscientific Implications

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### Introduction

When we explore music in neurological terms, the neurology that we find, and the neurology that we might expect to find, is influenced by what we mean by the term ‘music’. In this chapter, I shall be arguing that what we currently know of music in neurological and neuroscientific terms is constrained by a conception of music that is narrowly shaped by historical and cultural notions of what constitutes ‘music’. I shall suggest that music, rather than simply being a complex sonic pattern produced and received for aesthetic or hedonic ends, can better be interpreted as a communicative medium complementary to language that is deeply embedded in, and that may be foundational in respect of, the species-specific human capacity to manage complex social relationships (see Herrmann *et al.*, 2007).

In order to ground this argument, it may be helpful to consider two musical examples. The first consists of an audience listening to a performer in a Western concert hall. This constitutes an example of what might be called ‘music-as-display’, and is fairly typical of music as it tends to be conceived of within contemporary Western — and increasingly global — culture. This is an apparently quite conventional

musical scenario; a performer performs, and an audience listens. In this situation, music may appear to be akin to chess, or perhaps gymnastics, a result of long training, motoric skill and muscular resilience (on the part of the performer, and sometimes, the composer), yet comprehensible by virtue of being rooted in general cognitive and neural processes. The underlying biology appears to be a biology of perception and action control, albeit one that may be shaped (on the part of the composer and performer) by specialised training and learning but that is rooted in general biological process, as is evidenced by the capacity of the audience to engage with the music by virtue of enculturative processes rather than formal learning. Most of what we know about the neuroscience and neurology of music derives from this type of musical situation — indeed, it derives largely from one side of this situation, that of the listener.

But now let us explore another type of musical situation, involving a group of people, none of whom have been formally musically trained, singing and dancing together, stamping their feet, slapping their bodies and hissing rhythmically, creating the illusion of a percussion accompaniment to the singing. The text that they sing veers between praise of Allah and praise of their local councilman for the efforts that he has put into establishing a local AIDS clinic. This is a brief description of a recent *Dakira* performance from northern Mozambique (from the work of my graduate student Lydia Slobodian), in which all members of the community are as likely to participate as performers as they are simply to spectate and listen. This second type of musical situation — engagement with music through interactive performance and appraisal — is probably more characteristic of music in the majority of world cultures (and certainly in all known traditional cultures) than is the type of situation where a performer performs and an audience simply listens (see, e.g., Blacking, 1976; 1995). The biology that underlies this collaborative performing situation requires to be understood not only as concerned with perception and action control, but also with social interaction and communication. Considered from this perspective, music appears likely to be rooted in neural circuitry and social processes that overlap, or share features with, those that constitute the matrix of language.

## Language and Music as Universal and Discrete Human Capacities

Language is a universal human faculty; all humans (except those suffering from a pathological condition) are able to acquire the use of language; for all humans, the acquisition of language depends on engagement in linguistic interactions within a sensitive period (generally, from birth to around four to five years of age); and language is specifically human in that it is not acquired spontaneously by members of other species, and only acquired to a rudimentary level by our closest primate relatives (Pinker and Jackendoff, 2005; Hauser, Chomsky and Fitch, 2002; Nowak, Komarova and Niyogi, 2002).

Language seems to be a discrete capacity in that although it is implicated in most other domains of human behaviour, it appears differentiable from them on the basis of its complex and propositional intentionality; language is generally about something (an object, event, belief, or goal), and the use of language, unlike any other mode of human behaviour, enables the ‘something’ in question to be specified (see Pinker, 1994). The neural correlates of language in production and perception have been found to overlap significantly with those of other aspects of human action and perception (such as theory of mind, object perception, etc) as might be expected of such a multi-functional and ubiquitous mode of human interaction with the world, but some areas do appear to be specific to language, being largely lateralised in the left hemisphere and involving a network that incorporates Broca’s area, known to be involved in the processing of hierarchical sequence structure (see Friederici *et al.*, 2006).

Is musicality also a universal and discrete human capacity? This question has been answered variously and differently, and answers depend on what is intended by the term ‘music’ in research that purports to address this question. At least in part, it can be suggested that some of these difficulties of operational definition arise from the different evidentiary bases on which we can make claims about language and about music. Questions of universality and discreteness can be asked about language largely because language research is grounded in a large body of comparative data gleaned from very many

different languages, which enables cross-cultural regularities of linguistic behaviour and cognition to be identified (see, e.g., Comrie, 1989). Such a body of comparative data does not exist for music; in general, from cross-cultural perspectives, music does not appear to be identifiable on the basis of regularities of usage and of structure in the way that language is.

Conventionally, music has tended to be partitioned into pitch structure and rhythmic structure, and insofar as any cross-cultural comparative studies have been conducted, they have tended to focus on perception and cognition of music in terms of one or other of these structural aspects. However, within the cognitive science and neuroscience of music, the overwhelming majority of research has explored the cognitions and neural processes of Western listeners and performers in respect of Western music (largely, that of the Western common-practice period); hence scientific studies of music are not in any position to elucidate putatively universal features of music as a human capacity. Nevertheless, research within this tradition, focusing on Western musical cognitions and behaviours, has been brought to bear on the issue of whether musicality constitutes a discrete human capacity with identifiable and distinct behavioural and neural correlates.

### **Amusia as an Indicator of Domain-Specificity/Modularity**

On the basis of a long-term research programme, reported in a substantial series of publications, Isabelle Peretz has suggested that the basis for music in cognition and neurophysiology is modular, and that there are specialised brain processes for music, in particular, musical pitch (Peretz and Coltheart, 2003). Much of that research programme has been concerned with the exploration of the phenomenon of *amusia* — the incapacity to process musical information coherently, first named as such by Knoblauch in the nineteenth century (Johnson and Graziano, 2003). Peretz and her collaborators have demonstrated that the condition may be either acquired or congenital (Ayotte, Peretz and Hyde, 2003; Peretz and Hyde, 2003); it involves a ‘double dissociation’ between speech and music (evidenced

in the discovery that individuals may have an inability to deal with semantic and/or syntactic aspects of speech while preserving musical and intonational capacities, or *vice versa*).

For Peretz (2006, 12), such a finding ‘implies the existence of anatomically and functionally segregated systems for music and speech’, and leads her to suggest that, for musical cognition, (*ibid.*, 8), ‘components, especially those involved in pitch-based computations, rely on domain-specific mechanisms and specialised neural networks’, and are hence modular. Hence (*ibid.*, 9), ‘encoding pitch in musical contexts appears to be a domain-specific ability that can be localised in the adult brain’. It is important to note that Peretz’s research identifies the condition of amusia with an inability to process *pitch* in musical contexts; amusics typically perform in much the same way as ‘normal’ individuals in rhythm-based tasks; as she states (*ibid.*, 14): ‘To date, however, only abilities related to fine-grained processing of pitch appear to be uniquely engaged in music.’

Of course, as Peretz herself notes, the idea that a particular capacity is modular (or even domain-specific) does not imply that that capacity can be correlated with specific brain locations or neural networks. Indeed, the inability of amusics to process fine-grained pitch structures has not been localised to or identified with specific networks; it is not simply identifiable with deficits either in the peripheral auditory pathway or in the primary auditory cortex (superior temporal lobe). However, as Peretz and Hyde (2003) note, structures in the rostromedial prefrontal cortex that have been identified as operational in judgments of pitch relationships (described by Janata *et al.*, 2002, 2169 as ‘a nexus... for mediating interactions between sensory, cognitive, and affective information’) seem to be good candidates for a prospective brain area where such processes might be carried out. More recently, Peretz (2006, 9) has suggested that a lack of connectivity to the inferior frontal gyrus may be responsible for congenital amusics’ incapacity to deal with musical pitch in perception. It remains to be seen whether or not amusics demonstrate atypical activity (or lack of activity) in these areas when engaged with music.

Peretz may be right in identifying the human capacity to engage with music with the ability to process fine-grained pitch structures

and relationships. However, it should be noted that all the research that points to this conclusion has been conducted using Western-encultured participants, and has overwhelmingly employed musical examples that conform to Western common-practice musical principles. Before any firm conclusions can be drawn, there is a need to extend the range of types of pitch discrimination capacities beyond those that have been explored, in particular, a need to explore pitch discrimination capacities and propensities in other cultures. Moreover, it also remains to be seen whether or not the brain structures hypothesised by Peretz as implicated in the processing of musical pitch are consistently implicated in representations of musical pitch for members of non-Western — particularly, traditional — cultures.

Peretz, particularly in her modular theory of musical processing in the mind, is happy to posit a clear distinction between processes that are domain-general and those that are wholly specific to music. However, this picture is complicated by recent findings reported in Patel *et al.* (2008) which indicate that some amusic individuals also have difficulty in processing speech intonation patterns, which might be taken to imply that in some cases amusia is not dissociable from the phonological (and pragmatic) aspects of speech and casts some doubt on the modularity hypothesis.

## **Action, Interaction and Rhythm as Adaptive Behaviour**

For the most part, the cognitive science and neuroscience of music has tended to focus on individual responses to music, or on individual musical receptive behaviours, with little sense that music may involve action. However, a few studies have pointed towards the active dimensions of musical behaviour; a meta-review by Janata and Grafton (2003) demonstrated that even apparently ‘passive’ listening to music tended to elicit activation in premotor regions of the brain concerned with planning for action, leading them to suggest that engagement with music is best conceived of as a perception-action cycle that necessarily involves, if not overt action, at least covert planning for action as an essential constituent of the experience.

These findings do point in the direction of the notion that music, like language, is a mode of interacting with others. But most current neuroscientific methods severely limit the extent to which an experimental participant is in a position to engage in any type of interaction. Indeed, it is only very recently that behavioural studies have begun to explore music explicitly as interactive behaviour (see, e.g., Moran, 2007). However, one aspect of music appears likely to be particularly fruitful as a window into musical interactivity: that of musical rhythm. Thaut (for a summary, see Thaut, 2005) has explored the behavioural and neural correlates of musical rhythm in a number of adaptive tasks, requiring participants to tap in synchrony with sequences of pulses that deviate from complete temporal regularity to different degrees. He and his collaborators have found (Stephan *et al.*, 2002) that adaptive responses (where participants manage to align the periodicity and/or phase of their tapping with an external signal that continuously deviates slightly from temporal regularity) appear to involve self-monitoring, may be either consciously or non-consciously — automatically — performed, and that, whether or not responses are conscious or automatic, participants can either be aware of their actions or not. Specific brain regions identified as being activated in adaptive synchronisation tasks are primarily parts of the cerebellum, basal ganglia, thalamus and areas in the prefrontal cortex; these areas and networks are implicated in a wide range of motoric and temporal behaviours other than just musical, lending credence to the notion that the correlates of musical behaviours in the brain are as likely to rest on domain-general processes as on domain-specific ones, and be as concerned with action as perception.

While these studies have been highly informative, they have focused on music as evidenced in individual responses and action capacities. In an exploration of music as an interactive and social phenomenon, Himberg (forthcoming) has been conducting a series of behavioural experiments on interactive rhythmic behaviour, requiring pairs of participants to tap along with each other under a variety of experimental conditions. The results of these experiments have shown that participants strongly prefer to entrain with other humans rather than with a non-responsive pacing signal. To explore the factors that

appear to lead to this preference, an experiment was conducted in which an ‘averaged’ playback of human tapping on computer was substituted for one participant without the knowledge of the other participant. Participants demonstrated less co-ordination with the recorded tapping than with ‘live’ human partners. In these experiments it appeared that participants were highly attuned to the presence of their tapping partners, being sensitive to the degree to which these partners engaged in processes of mutual co-adaptation of phase and period in their tapping to maintain perceived synchrony.

### **Music as Communicative Medium**

To summarise, neuroscientific research has suggested that the human capacity to engage with music is rooted in the ability to process fine-grained pitch structures and relationships and is domain-specific; it has also suggested that some domain-general aspects of cognition and neural functioning are implicated in the processing of music; and it supports the notion that active aspects of musical behaviours are rooted in domain-general processes and structures. However, the scope of neuroscientific explorations of music is limited by the constraints of the methodologies currently available. Moreover, both cognitive science and neuroscience have focused almost entirely on the processes involved in individual Western musical cognitions — particularly, listening — with almost no research exploring other modes of engagement with music, or engagement with music in the contexts of non-Western cultures.

This raises the question of how music is being operationally defined within neuroscientific and cognitive research. In general, it appears to be being addressed as an auditory pattern of which the primary ‘musical’ features are constituted of complex pitch and rhythmic structures, and brain areas that have been proposed as specialised for music tend to be those associated with auditory perception and with information integration across different domains. Music appears to be conceived of — is certainly being explored as — individual responses to complex sonic pattern. While this conception of music may apply in situations such as the ‘music-as-display’ scenario, it does not seem

adequate to address the complexities of music as an interactive medium, as in the second scenario sketched at the outset.

When compared with language, it appears difficult to determine what might be the necessary and sufficient conditions for identifying music as a generic human capacity. Language can be described in terms of phonology, morphology, syntax and semantics, and its portrayal in terms of the features that it exhibits in these structural domains lies at the heart of the study of linguistic practices across different linguistic cultures. Music appears to lack equivalent, established structural features in terms of which it can be described cross-culturally. While some have been proposed by ethnomusicologists seeking a basis to compare music across cultures (Lomax *et al.*, 1978), and others have been proposed by scientists wishing to establish a basis for exploring music as a generic human capacity (see, e.g., Carterette and Kendall, 1999), counterexamples can be found in at least some musical cultures; indeed, the notion that ‘music’ constitutes a mode of human interaction that is clearly distinct from language appears absent in some emic cultural conceptions (see, e.g., the account by Lewis (2009) of communication among the Mbendjele hunter-gatherers).

Rather than focusing on structural features in attempting to define music, it may be more fruitful to evaluate whether or not music fulfils common functions within and across cultures and to define music in pragmatic terms. The ethnomusicological literature reveals that music fulfils a wide range of diverse functions in different societies, in entertainment, ritual, healing and in the maintenance of social and natural order (see, e.g., Feld and Fox, 1994; Nettl, 2005). However, it can be suggested that one very generic feature that all these functions appear to share is the management of social relationships, particularly in situations of social uncertainty. Recently (Cross and Woodruff, 2009), I have suggested that music as a universal human trait might be best conceived of as a communicative medium optimally adapted to manage situations of social uncertainty by virtue of its semantic indeterminacy or ‘floating intentionality’ and by the affiliative nature of musical interactions. Music manages social uncertainty in part by presenting the characteristics of an ‘honest signal’

(see Számadó and Szathmáry, 2006). It also under-specifies goals in ways that permit individuals to interact even while holding to personal interpretations of goals and meanings that may actually be in conflict, and music's exploitation of the human capacity for entrainment increases the likelihood that participants will experience a sense of joint action. In contrast to language, which can be thought of as being optimised to facilitate goal-directed social interactions, music can be thought of as facilitating social interaction *per se*, being essentially phatic.

Music in all cultures seems to exhibit this semantic indeterminacy, or 'floating intentionality'. Elsewhere (Cross, 2007; 2008; 2009) I have suggested that this is likely to arise because music may draw on at least three different dimensions simultaneously that endow it with meaning for performer and listener, or for participants, and that each dimension can be considered to have a different time-depth in the course of human evolution. The most evolutionarily recent dimension can be termed *culturally-enactive*, and arises from the distinct types of meaning that can be attached to conceptions of music within particular cultures. An example might be the singing of *Abide With Me* at the FA Cup Final, an activity that would seem perverse in the context of a match between Glasgow Rangers and Glasgow Celtic, and positively incomprehensible in the context of a match between Boca Juniors and River Plate in Buenos Aires.

The second dimension is rooted in cross-cultural, vocal and gestural, commonalities of form in interpersonal communication. It could be referred to as prosodic, though the term *socio-intentional* better captures its applicability across all domains of human vocal and gestural communication. It is evident in the ways in which music embodies tonal shapes and rhythmic structures that appear homologous with those that are employed in linguistic interaction to convey particular pragmatic stances: that is, not *what* is said, but *how* what is said conveys or betrays the *attitude* or *intent* of the speaker towards what is said or towards their interlocutor. This second dimension can be thought of as having an evolutionary time-depth at least as great as that of communicative humanity and is likely to be species-specific and cross-culturally general.

The third dimension in terms of which music can be experienced as bearing meaning is species-general. It derives from the evolutionary binding between the form of an acoustical signal and the functions that signal may bear for sound-producers and sound-perceivers. The relationship is involuntary and reflexive, conditioned by its survival value for an organism (and species), and deeply embedded in the genomes of those species for whom sound carries survival-critical information. This dimension can be referred to as the *motivational-structural*, the acoustical structure of the signal impinging on, or being conditioned, by the motivational — affective — state of the organism that perceives or produces it. It is in respect of this dimension that music can be interpreted as constituting an honest signal. It is manifested in music's global structural characteristics, and can be interpreted as lying at the root of the effects that the musical signal has been shown to have on non-human species (Rickard *et al.*, 2005).

These three dimensions of meaning operate simultaneously in any musical experience, allowing for volatile meaning to migrate between dimensions and enabling participants in collective musical behaviour each to interpret the purpose and function of that behaviour to their own ends without impairing its collective integrity. And that integrity is likely to be maintained by the possibility of entrainment — of temporal alignment if not synchrony between participants' behaviours — which is likely to promote a sense of group affiliation. Taking the proposal that music is a communicative medium optimal in the management of situations of social uncertainty as an operational definition of music, it would suggest that, across cultures, core musical behaviours — and brain areas activated in music — are likely to be those implicated in situation-specific social interactions that are oriented towards the reduction of social uncertainty. Such a hypothesis, though self-evidently broad-brush, might be of use in explorations of the behavioural and neural correlates of musicality as a universal human trait.

## Music and the Social Brain

The 'social mind' and the 'social brain' have become, in recent years, major foci for cognitive and neuroscientific investigation, in part

precipitated by the realisation that the complexity of human sociality is one of the principal defining characteristics that differentiates us from other species (see, e.g., Tomasello *et al.*, 2005; Herrmann *et al.*, 2007). Behavioural research has focused on issues such as theory-of-mind (concerning the cognitive processes whereby inferences are made about others' states of mind), social reasoning, and decision-making, and has often adverted to evolutionary approaches in seeking explanations for the scope of, and the constraints on, human social behaviours (see chapters in Dunbar and Barrett, 2007). Neuroscientific research has begun to turn its attention to these and other aspects of human social capacities, and a helpful overview is provided in Adolphs (2003). He notes that together with limbic regions, the orbitofrontal cortex is clearly implicated in most aspects of social cognition, suggesting that (*ibid.*, 175) it might be 'specialised for social and moral judgements', although limbic regions, concerned with affect or emotion, are also central to social cognition.

Adolphs proposes that the social mind-brain can be conceived of in terms of generic reward/punishment or approach/withdrawal systems, though noting that while this may constitute a useful first approximation, the binary dichotomy that it suggests might be too coarse-grained for adequate behavioural and neural analysis. Nevertheless, in the context of Adolphs' proposal, music, as a communicative mode optimised for the management of social uncertainty, might be conceptualised as facilitating 'approach' or 'affiliative' behaviours, as opposed to 'avoidance' or 'withdrawal' behaviours. One might thus expect to find that engagement with music primarily involves behaviours, and motivates neural structures and networks that are involved in initiating and sustaining approach-affiliative behaviours. While the hypothesis appears almost self-fulfilling at the behavioural level, it would be difficult to test by means of current neuroscientific method as it would require that the focus of study be shifted to explore much more 'ecologically-valid' engagement with music than is currently achievable.

It would be critical to identify the loci and networks whereby music achieves these ends, and to explore the extent to which they are differentiable from those implicated in other domains of human

behaviour. Some preliminary theories have been developed; for instance, Molnar-Szakacs and Overy (2006) present a theoretical account of the neural substrates that are associable with music construed as an active, interactive and affective behaviour. And of course none of the foregoing is intended to suggest that the results and foci of current research on the neuroscience of music should either be ignored or discounted. On the contrary, the notion that music should be explored primarily as a social and interactive medium seeks to provide an extended context for their conduct and interpretation by focalising the ways in which music as social act engages the pitch and rhythm systems identified by Peretz, Thaut and others in ways that are shared with, or are distinct from, other modes of human communicative interaction such as language.

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