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Music's "design features": Musical motivation, musical pulse, and musical pitch

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• **Abstract**

This paper focuses on the question of what music is, attempting to describe those features of music that generically distinguish it from other forms of animal and human communication — music's "design features". The author suggests that music is generically inspired by *musical motivation* — an intrinsic motivation to share convergent intersubjective endstates — and is universally identifiable by the presence of *musical pulse* — a maintained and volitionally controlled attentional pulse — and/or *musical pitch* — a system for maintaining certain relationships between pitches. As such music's design features are viewed as providing an interpersonal framework for synchronous and group affective interaction. The implications of this approach to an evolutionary perspective on music and on arguments of the primary evolutionary functionality of musical abilities in human evolution are discussed.

Keywords: music, evolution, comparative, specificity, universals.

Introduction

Music is increasingly a focus of attention in evolutionary debates and publications (*e.g.*, Wallin *et al.*, 2000; Morley, 2003; Balter, 2004; McDermott & Hauser, 2005; Cross & Morley, in press). A key enabling factor of these debates has been an ever-increasing acceptance of the value of the field of music psychology both intrinsically and in terms of its relevance to broader academic investigations. Musical scholarship has benefited enormously from multi-disciplinary perspectives (*e.g.*, Clayton *et al.*, 2003; Miell *et al.*, 2005; Peretz & Zatorre, 2005) and it is now widely accepted that music and music psychology offer invaluable insights and means towards furthering understanding in all fields related to human cognition and sociality. An evolutionary perspective on music as well as being of interest in and of itself has the additional value that it provides a common ground for multiple perspectives. Following Cross (2003), the great strength of this viewpoint is that by focusing upon phylogenetic relationships and the attributes that may allow a gene, a behaviour, an organism *or* an inter-personal/group dynamic to be functional, evolution uniquely offers an integrated framework for comprehending music, both biologically and culturally, within the wider context of human behaviour. In short there is an increasing convergence upon the notion that music and musicality are key features of who we — *Homo sapiens* — are both biologically and culturally.

Nevertheless, a clear psychologically and physiologically grounded and consensual model of music and musicality is lacking from the literature. Thus it is often unclear which aspects of an observed effect or proposed evolutionary functionality are due to specifically "musical" features and which are due to other aspects of the engagement. A biologically and culturally viable psychological and physiological model of musicality is an essential step towards clarity and understanding in this area and in all cross-disciplinary investigations involving music. A common argument of late has been that questions of definition are unnecessary as we all know what we are talking about (and by extension that we all know what each other is talking about) and that we are better off spending time on more productive empirical research (*e.g.*, Hauser & McDermott, 2006; Mithen, 2006). My reading of the literature, however, suggests that this is all too often not the case. I argue that, rather than taking time away from empirical research, a good and viable model could offer a foundation for inspiring and/or formulating testable hypotheses and greatly enhance the efficiency and applicability of empirical investigations.

The central aim of this paper is to address part of this need by presenting a concept and discussion of low-level features of musicality that are considered here to be species-specific, specific to the context of musical engagement, and universally present: Musical motivation, musical pulse and musical pitch. In other words this paper seeks to describe music's evolutionary "design features" — *i.e.*, those psychological and behavioural features that generically distinguish it from other forms of human and animal communication and hence may be considered to have evolved specifically for music.

Music, Communication and Affect

Music, like all human communicative activity, exists in and is reliant upon culture and interaction for the meanings and functionalities it embues. Outside the modern-day industrialised western world in which music is sometimes regarded as a commodity — a commercialisable physical object — music is essentially an active and interactive social behaviour. However, a seeming paradox is inherent in the widely established facts that musics' meanings essentially result from cultural processes and social contexts (*e.g.*, Blacking, 1995; Bohlman, 2000) but that we nevertheless appear able to engage appropriately with and/or respond to *some* aspects of musics outside of our own culture (*e.g.*, Balkwill & Thompson, 1999; Krumhansl *et al.*, 2000; Nan *et al.*, 2006). Even non-human species are responsive to a selection of generic structural features of music (McDermott & Hauser, 2005). This supposed paradox, though, need not be such if we accept the notion that musical engagement is operational at distinct, yet possibly overlapping, biologically, socially, and culturally grounded dimensions of meaning and affect (see Cross, this issue).

A special function for music is commonly attributed to its association with "emotion". Despite a wealth of anecdotal evidence that musically relevant emotion is in someway unique or special, the literature has so far not managed to satisfactorily address why that may be the case. Sensations of "peak experience" (Maslow, 1968), "flow" (*e.g.*, Csikszentmihalyi, 1990), and "shivers" or "chills" (Panksepp, 1995) have all been reported as evidence for the potential for particularly strong emotional experiences with music (see Gabrielsson, 2001). However, these experiences are relatively rare and perhaps not the best ground for a generic comparative perspective on musical emotions. Dynamic "vitality effects" (*e.g.*, Stern, 1985) or the intrinsic creation of tensions and expectancies (*e.g.*, Meyer, 1956; Steinbeis *et al.*, 2005) in music may engender some music-specific emotional reactions. However, as yet there exists to my knowledge no solid evidence that musical emotions are in anyway distinct from other forms of emotions. In terms of the expression of emotion a meta-analysis of studies (Juslin & Laukka, 2003; see also Thompson & Balkwill, 2006) confirms that vocal and music "expression" involve similar structural cues such as overall F0, pitch level, rate, and intensity.

Whilst the majority of studies in this area have focused on the expression of emotion in music, perhaps the most prevalent use of music in society is as a means of altering individual and group mood (Bailey & Davidson, 2005; DeNora, 2001; Gomart & Hennion, 1999). Despite lacking a clear theoretical underpinning, music's ability to function at this level is so well acknowledged in many areas of psychology that numerous experimental paradigms regularly use music as a means of inducing particular moods in participants based on the simple notion that it works (see Albersnagel, 1988; Gerards-Hesse *et al.*, 1994). It is notable that although other forms of communication may embody this functionality, music appears to be particularly efficacious (DeNora, 2001). One possibility is that the regular and sustained attention to affective material afforded by music is particularly conducive to resetting baseline affective states (*i.e.*, Moods [see Davidson, 1994]). Once again research has focused on the "listener" experience (hence "induction"). However, broadening the relevance to generic interactive contexts, it seems fair to state that in musical engagement participants are regulating each others' affective states and that this interplay is a key component of an individual's motivation to engage with music (Swaine, personal communication).

Musical Motivation

Motivation is broadly describable as 'a modulating and coordinating influence on the direction, vigor, and composition of behaviour. This influence arises from a wide variety of internal, environmental, and social sources and is manifested at many levels of behavioural and neural organisation' (Shizgal, 1999, p. 566). In musical scholarship, generic discussions on motivation appear to be absent. Only in neurophysiological literature on music therapy do we find reference to the need for a model of motivation for music (Unkefer & Thaut, 2002). However, even here an explicit model has, to date, not been offered. A failure to consider motivational factors in engagement in music has wide-ranging implications. First off the affective nature of music can never be fully understood without at least a conceptual model of the motivational forces that engender and sustain engagement (Thaut, 2002). Secondly, comparative perspectives are necessarily incomplete without considerations of motivation. Crucially, the functional/adaptive significance of a given set of behaviours is as much dependent on the biological and/or cultural forces that motivate a species to perform and/or sustain them in appropriate contexts as they are on the capabilities that underlie them.

The psychological literature on motivation identifies two main forms of motivation — intrinsic and extrinsic. Intrinsic motivation is described in Ryan and Deci (2000) as "the natural inclination toward assimilation, mastery, spontaneous interest, and exploration that is so essential to cognitive and social development and that represents a principal source of enjoyment and vitality throughout life (Csikszentmihalyi & Rathunde, 1993)". It is clearly evident in healthy children's inquisitive, curious, and playful behaviours in the absence of rewards (Harter, 1978), and is most evident when infants are securely attached to a parent (Bowlby, 1979). Intrinsic motivation is "increasingly curtailed by social pressures to do activities that are not interesting and to assume a variety of new responsibilities (Ryan & LaGuardia, 2001)" (p. 71). The term extrinsic motivation, in contrast, refers to the performance of an activity in order to attain some separable outcome which in turn can be characterised as a striving for reward (approach) or motivation to evade punishment (avoidance) (Norman & Shallice, 1980; Elliot & Covington, 2001). Of course music making can at times be extrinsically motivated (*e.g.*, auditions, seeking of fame *etc.*). However, the vast majority of musical engagement worldwide is "playful" and socially exploratory (see Cross, 1999). Negative valence in music (and logically a subsequent curtailment of motivation) is nearly always the result of extrinsic pressures (Steptoe, 2001) and people will consistently report that their most enjoyable and meaningful musical moments have come when they felt they could "just let go".

Specific features of musicality, as will be expanded upon below, provide a temporal and/or pitch based framework for synchronous interpersonal interaction. As such, musical engagement involves the conception and maintenance of shared intentions (see Miell *et al.*, 2005). Tomasello and colleagues (2005) argue very broadly that joint intentionality is a specific and defining feature of human psychology and describe shared intentional actions as shared goals and coordinated action plans. Furthermore, they view the regulation of intentional actions in terms of principles of cybernetic control, which serve to adjust actions in order to minimize the discrepancy between the actual states and the goal states of the interactants. Considering these facets and the fact that music is operational in eliciting and regulating affect (see above) it seems likely that intersubjectivity[1] is the proximal goal of musical interaction[2] and that musical interactants, by interacting within a mutual and synchronized framework, are motivated to share convergent psychological states. Swaine (forthcoming) argues that the shift from an extrinsic motivation to an intrinsic motivation to share psychological states, and the generation of matches between the actual state of the interactants and the desired intersubjective end-state in vocal musical engagement, serve to focus attention on action towards the proximal goal of intersubjectivity. Thereby, he argues, musical engagement promotes positive affect (*e.g.*, Bailey & Davidson, 2005). It is worth noting that although this is not yet a fully established idea in music psychology, the idea that music is driven by a goal of intersubjectivity and affect regulation is foreshadowed in the infant developmental literature and therapeutic applications. In these proto-musical and musical engagement/"musicking" (Small, 1998), the co-regulation of affect and motivational states, and the maturation, development, and repair of intersubjectivity are seen to be inextricably linked (Papoušek, 1996; Bunt & Pavlicevic, 2001; Trevarthen & Aitken; Beebe *et al.*, 2005).

Musical Pulse and musical pitch

A substantial component of the difficulty in defining music and musicality, psychologically or in terms of its physical correlates, is that its cultural manifestations, rationalisations and contextualisations are immeasurably variable (Nettl, 2000). This variability stretches so far that directly comparing two contrasting genres can appear to reveal very little, if any, describable overlap despite the fact that both are recognizable as being "music". Consider, for example, attempting to compare Tibetan monotone chanting with Japanese taiko drumming and, worse still, attempting to explain to an alien species why we consider them both to be music whereas mother-infant interactions are considered to be merely "proto-musical", and chimpanzee pant hooting is generally not considered to be music at all. One approach to the problem of universals in music has been to focus on infant processing predispositions (Trehub, 2000; Trehub & Hannon, 2006). Trehub claims that "universals of musical pattern processing have provocative parallels in universals or near-universals of musical structure" (p. 427). It seems very likely therefore that it should be possible to identify low-level universal features that constitute the building blocks of an inherent capacity for musical interaction upon which cultural variation is built and/or constrained.

A temporal organization of action (*i.e.*, pulse and rhythm) and frequency-based organization (*i.e.*, melody and harmony), are widely considered to be the fundamental, descriptively and neurophysiologically (Peretz & Zatorre, 2005) distinct, features of music. To encapsulate fully a low-level inherent capacity observable in all musics, however, we need to consider that not all musics employ an observable temporal pulse (Clayton, 1996); that some musics are entirely non-pitch based; and that an engagement with musical pitch need not imply melody, harmony or the use of scales (*e.g.*, monotone chanting). With this in mind specific features of musicality are described here as a species- and context-specific ability to engage with *configurations* of musical pulse and/or musical pitch (described below). Whether or not one or the other is absent, musical pulse and musical pitch appear to provide a framework for synchronous interpersonal interaction — a coordinating strategy.

Musical Pulse

In a recent paper (Bispham, 2006b) I provided a psychologically and physiologically grounded cross- and intra-species comparative perspective on musical rhythmic behaviour. The main goal of this was to identify features that are unique to — and defining of — rhythm in music. The following section summarises the main points from this paper but the reader is referred to the original and to a more recent paper (Cross *et al.*, in press) for more detail and discussion on how this impacts on broad evolutionary perspectives of rhythm and entrainment.

The crucial — arguably defining — feature of musical rhythmic behaviour is that the temporal structuring of actions is built upon a pulse containing regularities that allow individuals, within temporal boundaries of a psychological present (Fraisse, 1984; Clarke, 1999), to interact in real-time through a process of entrainment (Clayton *et al.*, 2003). Entrainment occurs as individuals use regularities in the signal to predict and direct attentional resources towards the timing of future events (Jones, 1976) and can be viewed as an essential component of all temporally structured ecological engagement across taxa. Entrainment has also been proposed as a mechanism that provides a mutually manifest pulse-based temporal framework for communication in mother-infant and linguistic interactions (Webb, 1972; Jaffe & Anderson, 1979; Auer *et al.*, 1999). In human development, it has been claimed that even neonates demonstrate a capacity to entrain with the movements and sounds of a caregiver (Trevarthen, 1999). Nevertheless, it appears that there are unique or extended psychological and/or physiological features in musical entrainment that follow non-musical forms ontogenetically and possibly phylogenetically. Bahrick and Lickliter (2004) suggest that infants of around 5 months require multi-modal cues to detect rhythmic changes, whereas 8-month-olds are capable of employing single sensory modalities in such tasks. Phillips-Silver and Trainor (2005) have shown that unless infants of 7 months are moved in time with the metre of a piece of music, they are unable to discriminate between different metric groupings. It seems that the ability to entrain with musical material does not fully emerge until after the first year of life (Hannon & Johnson, 2005; McAuley *et al.*, 2006).

As explained in Bispham (2006b), there are two contrasting ways of interpreting the difference between the type of pulse operational in music and that in other forms of interaction. Firstly, one can argue that human interaction of all kinds is composed of forms of interpersonal entrainment ranging along a spectrum from (a), a loose, subconscious use of pulse as a framework for interpersonal/turn-taking interactions in, for example, mother-infant or linguistic interactions (Wilson & Wilson, 2005) with deviations from expectancy used for affective/communicative purposes to (b), a strict adherence to pulse (groove) in group musical behaviour and synchronicity of output where participants are aware of the pulse framework and desire to maintain a degree of temporal stability and group-coordination (*e.g.*, music and dance). An alternative possibility is that the appearance of pulse in non-musical interaction does not depend on entrainment mechanisms similar to those employed in music and is the result of organising actions in relation to short-term and constantly interrupted pulses and expectancies based upon temporal cues and experience. Whichever of these proves to be correct I argue that there are, at the very least, features of rhythm in music that can be described as being contextually and mechanistically distinct and hence cannot be explained as having evolved with relation exclusively to non-musical behaviours.

In contrast to non-musical interactions and supposed analogous behaviours in other species, pulse in music is sustained over time, incurs awareness of a pulse-based framework (Repp, 2001), and is perceived unambiguously or at related hierarchical levels (London, 2004), by enculturated individuals (Stobart & Cross, 2000). Furthermore, engagement with a musical pulse entails activation of the motor system such that it potentiates an individual to manage both fine and gross temporal control in ballistic and smooth movements (Thaut *et al.*, 1997). This would appear to involve internal periodic oscillatory mechanisms overlapping with motor-coordination (Bispham, 2003). Additionally achieving the desired goal of maintaining an interactive "real-time" temporal framework and sensorimotor synchronization involves correction mechanisms, based on the output of self or others. These are essential to account for motor variances (Wing & Kristofferson, 1973), and conscious and subconscious expressive and structurally inspired modulations of tempo and microtimings (Palmer, 1997; Collier & Collier, 2002; Iyer, 2002). Recent neuro-imaging studies (Stephan *et al.*, 2002) and a considerable psychological literature identify two interacting correction mechanisms that are widely accepted to be independently operational in music: phase correction and period correction (Repp, 2005)[3]. In contrast to period correction, phase correction mechanisms are most likely common to all activities involving future-directed attending where expectations are continuously adjusted to account for divergences between separate attentional pulses and stimulus events. Period correction, however, is almost by definition, functional specifically within the framework of a sustained musical pulse. Following Repp (2004) it is likely that period correction is a specifically human ability and is a manifestation of the more general human ability to set the tempo of a rhythmic activity at will. A final crucial feature of period correction mechanisms is that, again in contrast to phase correction mechanisms, they seem to incur awareness (Repp, 2001) and are affected by manipulations of intention, attention and awareness (Repp & Keller, 2004).

Musical Pitch

Certain universals in terms of the organization of pitch in music have been proposed (Justus & Husler, 2005; McDermott & Hauser, 2005) including the presence of unequally stepped scales (Burns & Ward, 1999); a dominance of and "preference"[4] for small-integer value intervals (Dowling & Harwood, 1986; Schellenberg & Trehub, 1996); and tonal hierarchies (Castellano *et al.*, 1984; Krumhansl, 1990). I agree that these features would appear to be at least near-universals. However, scales and tonal hierarchies are both culturally constructed and are not an absolute requisite for pitch-based interaction to be "musical". In order to encapsulate all instances of musical pitch (including, for example, monotone chanting) whilst addressing the issue in terms of its being an emergent capacity for musicality, we need to delve to a yet lower level. I tentatively suggest that musical pitch in all forms is built upon a primary ability to produce and engage with a sustained stable fundamental frequency and the ability to create or process certain relationships between pitches. This is built on the hypothesis that musical pitch structure worldwide — whether monotone or florid — can be characterized as being relationally organized with reference to sustained yet variable tonal areas (McAllester, 1971). This may appear controversial to some but, importantly, does not imply any form of structured tonality; it merely suggests that musical pitch at any given time (or possibly within phrase boundaries) is organized relationally within a framework of a dominant pitch region or regions[5].

The production of a sustained fundamental frequency as well as more complex forms of musical pitch are reliant upon an ability to produce sound that independently varies in loudness, pitch (F_0), and timbre. This is not trivial and it seems, at least in terms of vocal production, that this ability is not shared with other primates who exhibit a close linear relationship in vocalization between F_0 and intensity with changes to subglottal pressure (Demolin, 2006). The ability to sustain stable F_0 and independently vary acoustic correlates of vocalisation appears gradually in human infant development (Wermke & Mende, this issue) and is achieved by independent control of numerous muscles involved in vocal production: Glottal adductor and abductor muscles serve to open and close the vocal folds that regulate levels of subglottal pressure thus affecting F_0 and intensity; pharyngeal constrictor muscles control the width of the pharynx hence altering the relationship of f_0 and higher harmonic partials (*i.e.*, timbral correlates); extrinsic laryngeal muscles control the vertical positioning of the larynx in the throat; and intrinsic laryngeal muscles modulate length, stiffness, and thickness of the vocal folds through contractions of the cricothyroid and thyroarytenoid muscles and crucially allow an uncoupling of intensity and F_0 (Sundberg, 1987; Titze, 1994). It seems likely that volitional control of these muscles and subsequent ability to independently vary F_0 and intensity is unique or especially developed in humans. It is interesting to note that although little comparative work has been done the thyroarytenoid muscles in humans uniquely exhibit rare slow tonic muscle fibers that unlike most muscles do not twitch and sustain prolonged, stable, precisely controlled and fatigue resistant contractions (Han *et al.*, 1999). Another crucial feature, of course, is breath control and it is certainly significant that increased thoracic innervation in the course of hominid evolution has been argued to demonstrate improved fine breath control in modern humans and Neanderthals (Maclarnon & Hewitt, 2004).

Although the above paragraph focused on vocal production, the principles may be generalisable through the notion that all engagement with music involves "inner singing" (Janata, 2001; Kalakoski, 2001). This remains a supposition but is supported by a recent neurological study showing that areas of the Rolandic operculum, in particular those areas that are likely to represent laryngeal and pharyngeal articulation, were activated during the emotional processing of instrumental musical stimuli (Koelsch *et al.*, 2006). It also appears consistent with pedagogies (*e.g.*, Kodály) that claim that the human voice is the natural musical instrument. It would appear a realistic hypothesis that the uncoupling of F0 and intensity/volume is generically more pronounced in music than in speech. This would perhaps explain some puzzling comparative findings that pitch changes had opposite effects on valence for music and speech, and affected subjects' measurement of energy-arousal only in speech (Ilie & Thompson, 2006). Following Gussenhoven (2002), it may be that this uncoupling fundamentally changes the biologically rooted "production code" for music as apposed to speech and vocal communication more broadly.

A sustained stable pitch centre is in some senses similar to a sustained pulse in that it provides a mutually manifest framework for interaction. Analogously, also, engagement with musical pitch necessarily involves correction mechanisms based on the output of self or others and a desire to achieve and maintain certain frequency relationships. Although there is some debate as to whether absolute or relational processing represents the innate state (Saffron & Griegentrog, 2001; Trehub, 2003; Platinga & Trainor, 2005), it certainly seems safe to state that relative pitch processing represents part of an emergent capacity for musicality. Except for one highly unusual known example (Will, 1997) musical pitch systems across cultures are built upon and understood in terms of relative rather than absolute frequency connections[6]. In contrast McDermott and Hauser (2005) review that, with the exception of one study reporting octave equivalence in rhesus macaques (Wright *et al.*, 2000), it has also been consistently shown that other species seem to most naturally encode musical stimuli in terms of either absolute pitch or the absolute frequency content.

Correction mechanisms in engagement with musical pitch are as yet not well understood. However, on the basis of investigations with the voice feedback frequency shift paradigm[7] on auditory control of voice F_0 (Donath *et al.*, 2002) we can start to make some suppositions. In studies involving continuous vocalization, there is some evidence that opposing responses occur with a short latency of 100-150 ms (Burnet *et al.*, 1997), whereas following responses have a longer latency of 250-600 ms (Larson, 1998)[8]. The presence of two responses was confirmed by Hain and colleagues (2000), who found that the direction of the second response, but not of the first response, can be modified by instruction. According to Donath *et al.*, (2002) "the first response therefore indicates a negative feedback system stabilizing voice F_0 automatically, while the second response may reflect a voluntary mechanism, which adjusts voice F_0 to match an (supposed) external reference" (p. 1587). Interestingly, studies of speech (Natke & Kalveram, 2001; Donath *et al.*, 2002) have only shown opposing responses occurring with a latency of about 160 ms due to frequency-shifted auditory feedback. This indicates that in speaking only the first, involuntary responses occur and, together with the other evidence given, suggests that a music-specific volitionally controlled mechanism (somewhat analogous to period corrections to musical pulse) is operational in engagements with musical pitch. This needs to be empirically tested within a musical paradigm of fine tuning and matching output to external references.

On the functionality of music

The proximal functionality of the putative design features described above seems pretty clear. Musical motivation, musical pulse and musical pitch provide a coordinative framework for affective interpersonal interaction. Humans have an innate need for social interactions (Baumeister & Leary, 1995) and the basic perceptual and production abilities described enable an organization of time and pitch that possibly make music a particularly efficient means for facilitating these interactions. In contrast to other interactive frameworks operational in, for example, linguistic interaction, musical pulse and musical pitch allow individuals to share a more or less common and synchronised framework and allow group affective interaction. In accordance with this putatively defining characteristic, music may broadly be construed as operating towards achieving socio-affective confluence (Graham, 2007; Bispham, 2007). Viewing the functionality of music in this way makes particular sense in light of the universal use of music in ceremonial ritual where the desire to achieve, by means of social engagement, convergent motivational states in large groups of people would appear particularly desirable (see Rappaport, 1999).

However, an important point to make clear is that, although it may be parsimonious to assume that the two are related, the proximal functionality of an activity need not necessarily reflect its evolutionary significance. Albeit intuitive, it is not clear how a convergence of social and affective states in music (and ritual) might have impacted upon individual or group evolutionary fitness. An abundance of putative rationales for the evolutionary fitness of music capabilities have been suggested in the literature. These can be broadly categorised as relating to mate attraction (*e.g.*, Darwin, 1871; Miller, 2000; Merker, 2000); coalition signaling (*e.g.*, Hagen & Bryant, 2003; Hagen & Hammerstein, this issue); altriciality and mother-infant interaction (*e.g.*, Dissanayake, 2000, Falk, 2004); and group cohesiveness (*e.g.*, McNeill, 1995; Roederer, 1984; Brown, 2000a; Brown, 2000b; Freeman, 2000; Cross, this issue). Each of these perspectives has been able to acquire some considerable support and it seems fair to assume that music embodies and has embodied a multiplicity of functions.

It is not the purpose of the current paper to enter into debates on the relative weight that should be attributed to the various putative scenarios in the literature[9]. I do suggest, however, that debates on this matter need to be grounded in, and informed by, an understanding of the specificities of musical interaction and engagement. Music, like all complex capabilities, emerged as a result of a series of conglomatory evolutionary adaptations and/or exaptations (Foley, 2004). A full generic capacity for music incorporates skills and mechanisms that were putatively around in the earliest jawed vertebrates some 500 million years ago (Chase, 2001). Hence, to discuss the adaptive functionality of music or its status as an adaptation, exaptation or spandrel without first defining the matter for debate and its potentially unique design features is necessarily incomplete. Alternately, we are at constant risk of falsely attributing functionalities to "music" that are in fact more precisely attributable to broader categories of relevance.

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• Modelización de la música — motivación, pulsación y tonalidad musicales

Este capítulo presenta un modelo de motivación musical —una motivación intrínseca destinada a trazar finalidades intersubjetivas—; de pulsación musical —una pulsación atenta controlada continua y voluntariamente—; de tonalidad musical —una emisión sonora mantenida en la cual el volumen, la altura y/o el timbre varían de forma independiente—. Este modelo sería específico de las especies, específico del contexto, y tendría las características universales de una capacidad emergente para la musicalidad. En el seno de un amplio cuadro de comunicación humana y animal, el autor presenta el punto de vista según el cual la motivación musical y las configuraciones de la pulsación y de la tonalidad sirven para producir un conjunto coordinador para una interacción social eficiente al máximo y para la co-regulación óptima del fenómeno afectivo.

• Le "design features" della musica — motivazione, ritmo e tono musicali

Questo capitolo offre un modello della motivazione musicale — una motivazione intrinseca a condividere gli stati di arrivo (*endstaes*) intrasoggettivi; del ritmo musicale — un ritmo attenzionale mantenuto e volontariamente controllato; e del tono musicale — una produzione sostenuta di un suono in cui il volume, l'altezza e/o il timbro variano in modo indipendente, come aspetti specie-specifici, contesto-specifici e universali di un'emergente capacità musicale. In un ampio contesto di comunicazione umana e animale, l'autore presenta la tesi che la motivazione musicale e le configurazioni del ritmo e del tono musicali siano funzionali alla creazione di una struttura di coordinamento finalizzata alla massimizzazione di un'interazione sociale efficiente e alla coregolazione ottimale degli affetti.

• Modélisation de la musique — motivation, pulsation et tonalité musicales

Ce chapitre présente un modèle de motivation musicale — une motivation intrinsèque destinée à partager des finalités intersubjectives — ; de pulsation musicale — une pulsation attentive continue et volontairement contrôlée; de tonalité musicale — une émission sonore maintenue dans laquelle le volume, la hauteur et/ou le timbre varient de façon indépendante. Ce modèle serait spécifique des espèces, spécifique du contexte, et aurait les caractéristiques universelles d'une capacité émergente pour la musicalité. Au sein d'un large cadre de communication humaine et animale, l'auteur présente le point de vue selon lequel la motivation musicale et les configurations de la pulsation et de la tonalité servent à produire un ensemble coordinateur pour une interaction sociale efficiente au maximum et pour la co-régulation optimale du phénomène affectif.

• Die „Design-Eigenschaften" der Musik — Musikalische Motivation, musikalischer Puls und Tonhöhe

Dieses Kapitel präsentiert ein Modell der musikalischen Motivation (intrinsische Motivation, intersubjektive Endzustände gemeinsam zu erleben), des musikalischen Pulses (als willentlicher und bewusst durchgehaltener Puls) und des musikalischen Tons (als fortwährendes Klangergebnis, in dem Volumen, Tonhöhe und/oder Timbre unabhängige Variablen sind) als speziesspezifische, kontextspezifische und universelle Charakteristika einer sich entwickelnden Fähigkeit zur Musikalität. Innerhalb eines weiten Bezugsrahmens zur menschlichen und tierischen Kommunikation vertritt der Autor die Sichtweise, dass musikalische Motivation und Konfigurationen des musikalischen Pulses und des Tons funktionell einen koordinierenden Rahmen bieten, um mit maximaler Effizienz soziale Interaktionen und optimale Co-Regulierungen von Affekten zu erreichen.

Footnotes text

(1) Following Stern (1985) “intersubjectivity” is used as a blanket term to encapsulate interattentionality (or joint attention), interintentionality (shared intention), and affect attunement.
(2) As noted by Swaine (personal communication) this is most likely within a hierarchy of goals
(3) Phase correction adjusts for asynchronies between the last response and stimulus events assuming an unchanged period whereas period correction modifies the next target interval on the basis of discrepancies between the timekeeper interval and the last or last few inter-stimulus intervals thus altering the period of the attentional musical pulse.
(4) The notion of preference is problematic as “consonance” and “dissonance” are relative depending on musical styles. It is the interplay between “consonance” and “dissonance” and the creation of “tensions” and “resolutions” that is generically important.
(5) The suggestion that some form of drone is a near-universally present within individual cultural repertoires possibly adds some weight to this suggestion (Mâche, 2000). It may be, just as in many African musics the beat is entirely implied and assumed by enculturated individuals and is not made auditorily explicit (Arom, 1991), that dominant pitch areas are merely made more explicit through the use of drones.
(6) It certainly does not make sense to argue, as Mithen (2005) does, that the acquisition or retention of absolute pitch makes man or Neanderthal “more musical” (see Bispham, 2006a).
(7) In this paradigm subjects are required to wear earphones and hear their own vocal production in real-time. Typically perturbations to the heard frequency (or other acoustic features) are introduced and researchers investigate the effect on production.
(8) An opposing response is one where the F0 produced by the subject moves is the opposite direction to the manipulation to the auditory feedback. A following response obviously denotes the reverse.
(9) It is worth noting, however, that, as the design features described enable group interaction, the approach taken here would appear to support those hypotheses that describe group-level processes.