

The Antiquity of Musicality and its Role in Prehistoric Culture

Ted Bayne
Independent Researcher
West Tisbury, MA 02575 USA

Musicality consists of a distributed array of faculties and general substrates, each with its own deep history. In **part one**, a few key components of this array are reviewed to appreciate their antiquity including the salient neurobiological precursors to the underlying sociality. In **part two**: the role of this musicality in hunter-gatherer culture is examined whose peoples also have deep histories and leverage these faculties in polyphonic-polyrhythmic proficiency (Arom, 2004). It is assumed that between 200 and 100 kya, this array of faculties morphed into enculturated musical forms without leaving a trace. But in extant hunter-gatherers a *semiotic plasticity* is found where spoken language is just one modality blended with others. Musicality is critical to rituals that form the praxis of social memory. In collective performance, song/dance integrates the worlds of the spirits, the forest, morality, the hunt, and social homeostasis. Words alone could not achieve the affective and symbolic efficacy required. Very old anthropomorphic structures coalesce the seen natural world and the unseen (but “experienced”) spirit world. Ritualized musical forms demand a semiotic *channel* to bind human care to this humanized cosmology. A final section considers the implications of these topics for language evolution.

1. Antiquity of Musicality’s Underpinnings

1.1 *Four phylogenetic precursors critical to pro-social communicativeness*

(a) An autonomic social-engagement neurological subsystem developed on top of older sympathetic and much older parasympathetic systems. Evolved in the primate line over 15 my. (Porges & Carter in Narvaez et al, 2013:ch.5) (see §1.2 below); (b) The human “interaction engine”: a pre-linguistic set of capacities and drives (Levinson in Enfield & Levinson, 2006:ch.1; Levinson & Holler, 2014; Levinson in Arbib, 2013:ch.3); (c) Hierarchical Predictive Coding (HPC): predictive processes within cognitive supports of perception and motor, critical for communication (e.g. in Gricean turn-taking, a turn may take 200 ms yet single word latency may be 600 ms) (Shipp et al, 2013; Clark, 2013; Vuust et al, 2014); (d) Extended altriciality and neoteny: caregiver-infant preverbal/tonal IDS processed as “music” (Schorre in Narvaez et al, 2013:ch.2; Koelsch, 2013:244-248; Chang in Fisher et al, 2013:ch.8).

1.2 *Vocalization: cortical control, tracking melodic contour, pitch cognition*

Morley (2013:144-153, 214-227) carefully works through the evidence for when *Homo* was vocalization-ready. “...both early anatomically modern humans and Neanderthals *do* show modern thoracic vertebral canal development suggesting that such control over extended-duration vocalization has an ancient provenance and is not a feature solely of modern humans.” These and related developments occurred sometime after *H. ergaster*. For archeological evidence and a timeline see Tomlinson (2015:209-237).

Primate and early *Homo* lines saw the loss of fixed calls and a gain in cortical control producing wider range/repertoire in the context of sociality. The development of this sub-system is part of the larger neurobiological development of what has been called the social-engagement autonomic nervous system (ANS). Porges and Carter (in Narvaez et al, 2013:145) summarize the character of this latest layer in the ANS:

This synergism of neural mechanisms in mammals down-regulated defensive systems and promoted proximity by providing social cues (e.g., intonation of vocalization, facial expressivity, posture, and head gesture) that the organism was not in a physiological state that promoted aggressive and dangerous behaviors. Detection of these social cues allowed for symbiotic regulation of behavior and the elaboration of reciprocal care-giving.

Even in primates such as bonobos, vocal utterance is part of an integrated cluster of expressive physical features. Morley (2013:207-208) reminds us of this larger interactive process:

Amongst bonobos, utterances always occur along with facial expressions, and tactile communication, which is true for human ID speech too. Humans also use facial affect (emotional expression) and vocal affect to inform judgment about affective content of each other; they seem to be interdependent systems in both production and perception, with the former having had significant impact on the development of the nature of affective communication in the latter.

Gesture and speech systems co-evolved and leverage common neural/cognitive components. Evidence clearly points to vocalization being very old (Morley, 2014:148). And the notion of “speech vs. gesture” is a false dichotomy. Gesture and speech are a co-existing integrated system. (McNeill, 2012; Kendon in Dor et al, 2014:\$6.2; Levinson, 2014; Cole in Radman, 2013:ch. 1; Ghazanfar & Takahashi, 2014; Willems & Hagoort, 2007). Vocalization and bodily gesture grew up together and mirror each other. Selective pressure operated through social-engagement challenges. This aggregated a correlated set of neurobiological developments including gesture and vocalization as well as enhancements to the ANS.

Human processing of pitches is ancient. Archeological dating of the Swabian Jura pipes at 35-40 kya indicates that *H. sapiens* possessed a capacity to perceive, produce, and measure segmented pitches at a time considerably before those dates (Tomlinson, 2015:257-261; Morley, 2013:42-51).

1.3 Rhythmic entrainment and dance

The concept of *entrainment* covers a manifold continuum of inter-coordinated sociality addressing, for example, lithic technology and its related social learning as well as many other forms of shared temporality and rhythmicity (Tomlinson, 2015:76-84). Dance leverages bipedal rhythmic capacities that emerged before modern *H. sapiens sapiens*. Brown (2006), Merker et al (2009), and Ghazanfar & Takahashi (2014) have researched the origins of general rhythmicity and entrainment. Dance is intertwined with musical production and perception (Janata in Arbib, 2013:326-327). It is a cultural invention like song that ritually reinforces group cohesion, sacred beliefs, and social knowledge. "... dance, in the ritual setting, *is* a literature of the non-literate cultures." (Snyder cited in Royce, 2002:154) "Dance may in fact be as old as the human capacities for bipedal walking and running, which date back 2-5 million years." (Brown, 2006:1163)

1.4 The multi-modal brain: music, language, and action processing

The flexibility and domain-general plasticity of the human brain is widely accepted, an ancient adaptive advantage that builds and accumulates culture. The MNS (mirror neuron system) provides an imitative and interpretive power whether modeled on the target goal or the methodical steps. Wakita (2014) drove an investigation (using near-infrared spectroscopy - NIRS) that combined visual interpretation of *silent* action patterns along with the interpretation of the musical content *implied* by that silent action. The study found that "the notion that hierarchical processing in Broca's area is a common function shared between the language and music domains may help explain the role of Broca's area in action perception." Janata et al concur (in Arbib, 2013:325): "The involvement of Broca's area in language production, processing of musical syntax, abstract rule-action relationships in general, and connections to the lateral temporal lobe, makes it a likely substrate for controlling the integration of music, language, and meaning across multiple timescales."

And, finally, Koelsch (2013:§13.2) describes a single continuum and domain:

...overlaps of the cognitive operations (and neural mechanisms) underlying music- and language-processing indicate that 'music' and 'language' are different aspects, or two poles, of a single continuous domain ...the human brain, particularly at an early age, does not treat language and music as strictly separate domains but rather treats 'language as a special case of music' (Koelsch & Siebel, 2005).

2. Musicality's role in prehistoric cultures

Sub-Saharan hunter-gatherers have been studied since the 1960's and 1970's (e.g. Turnbull, Blacking, Arom, and others) with an emphasis on their musicality. Hewlett (2014:Intro) provides a survey and discussion of scholarship in this area since 1970 (see

also the studies referenced here). The very deep history of these peoples has re-emerged through recent mtDNA genetic study, particularly around the “out of Africa” question. Musicality has been a major factor in the *resilience* of these cultures over the course of tens of millennia in three ways: (1) a *semiotic plasticity*, (2) *social memory*, and (3) the *symbolic efficacy* of ritual in an anthropomorphic cosmology.

2.1 Congo Basin hunter-gatherers: first peoples?

These bands are archetypically aboriginal. Genetic data shows limited intermarriage with non-Pygmies until recently (Hewlett, 2014:Intro). They exhibit cultural practices that merge musical and verbal utterance and movement into a communicative continuum (Lewis in Arbib, 2013:47-50).

These [genetic] data showed that the Biaka [Aka] Pygmies have one of the most ancient ... sublineages observed in African mtDNA and, thus, that they could represent one of the oldest human populations. In addition, the !Kung [Bushmen] exhibited a set of haplotypes that were positioned closest to the root of the human mtDNA phylogeny, suggesting that they, too, represent one of the most ancient African populations. (Yu-Sheng Chen, 2000:1362 cited in Grauer, 2011:20-21)

There is significant cultural sharing of fundamentals among the peoples (“Pygmies”) that have been studied in this region. Moïse (in Hewlett, 2014:ch.4) provides a review of current scholarship on Pygmy *history* (after ~70 kya) while also critiquing tired sentimental perspectives that lack evidence. Pygmies have shown hardiness in the modern period despite Bantu/farmer and then colonial impacts. The Bantu period begins somewhere around 3.5-6 kya.

2.2 Antiquity of these hunter-gatherers: the consensus on “out of Africa”

A growing consensus has emerged on when the main migration occurred (~65-55 kya) (Mellars et al, 2013, 2013a), the genetic identity of these groups, the routes taken, and settlement areas (Dennell & Porr, 2014). It is tempting (Grauer, 2011:119) to draw inferences from the presence of the signature musical forms of Pygmy/Bushmen in places as far away as Papua New Guinea (specifically Lihir Island, New Ireland), especially when the genetic identity of the particular PNG people (Hg Q2. Corser, 2012) is a subgroup of the initial migrant parent group (Hg L3). Of course, those who migrated brought their culture with them. And it is likely that the original migrants had developed musical forms long before migration. Ritual musicality can have resilience similar to that of lithic technology itself due to its adhesion to survival activities. Given the wide variety of world musical forms with ancient roots (Jordania, 2011), the *re-creation* of these very same polyphonic/polyrhythmic forms seems unlikely. Lewis (in Arbib, 2013:64) shares a relevant anecdote: “Upon hearing [a recording of] Mbuti

music, the BaYaka immediately recognized that the Mbuti were ‘real forest people’ like themselves, even though genetic studies suggest that they last lived together around 18-20 thousand years ago (Bahuchet 1996).” They clearly detected shared structural-musical fundamentals after a separation of many millennia.

2.3 Semiotic plasticity: an articulatory continuum

Jerome Lewis in his study of the Mbendjele Pygmies goes right to the heart of what can be called a *semiotic plasticity*:

“Mbendjele have developed specific styles of communication for different audiences and situations. They mix words with sung sounds, ideophones, expletives, whistles, signs, hand signals, gestures, vocabulary from other people’s languages, animal sounds, and other environmental sounds, sometimes in a single speech act. In the context of forest hunting and gathering, the role of different language styles and communicative strategies suggests that diverse styles of communicating could have been crucial to the survival of early humans...” (Lewis in Botha & Knight, 2009:ch.13)

[For the Mbenjele ...] *It is not what people are singing but the polyphonic yodelling singing style, not which dances they dance or which spirits they call but the ritual structures they follow, not the language they speak but how it is spoken. The perception of what it means to be Yaka is based on an aesthetic quality and lifestyle as much as on genealogical accident, a distinctive sense of style in which music is more central to culture than language.* (Lewis 2002:68. Emphasis added.)

Some groups are so eclectic in language-use that a specific language cannot be used as a reliable group identifier. Their repertoire of communicative-expressive forms is an extremely versatile, speaking and listening to wide spectrum of beings: animals, spirits, farmers, etc. As Severi (2014:46,57) contends, this semiotic continuum blurs the distinctions between articulatory domains. In what has been called a “synesthetic fusion”, song and dance and visual narrative can all have shared meaning and common set of referents (see also Cross et al in Arbib, 2013:544). The modern sequestering of verbal language away from this articulatory continuum obscures its *roots*: an early development in a rich semiotic mélange containing gesture, dance, mime, song, polyrhythm, ridicule, mythology, and dialogic sociality. (see Arom, 2004:§2.4-§2.6).

2.4 Musicality and Social Memory

As Severi (2015:3) stresses, the ritual act itself is the sink of social memory not the “lyrics”. *Oral* cultures are not dependent on the memories of individuals thereby making them fragile. “[in these societies] the use of memory is extremely elaborate...

[these cultures] are founded upon ritual gestures and images as much as upon the use of speech.” (Severi, 2015:14) In the oral culture of these immediate-return hunter-gatherers, non-verbal expressive rituals (dance/song) are forms of kinesthetic social memory. There is no shamanic figure prompting people to “remember”. Daily collective practice touches on the status of the spirit world, re-asserts gender balance, and protects the moral homeostasis of the community. Egalitarianism along with continual vigilance about *autonomy* persists thanks to daily dialogic contention. The *very long-term* endurance of this culture grows out of an embodied syncretism of sacred narratives with the ethologies that express them providing a safe context for vivid differences while rarely turning to aggression. The egalitarian ethos wards off toxic or dangerous people. (Boehm, 2001; Lewis, 2002; Finnegan, 2008, 2013; Kisliuk, 2001).

Lewis (in Hewlett, 2014:ch.8) points to a nonlinguistic core of the Mbendjele form of social memory that blocks emergence of an *expert* who would exercise *authority*:

...institutions such as massana or ekila show how values and meanings can be condensed to establish a cultural store that ensures internal continuity between generations without attributing special status or authority to individuals. Their basically nonlinguistic nature means that it is difficult to articulate them explicitly as a coherent body of ideas.

2.5 Musicality and Ritual: a Cognitive Symbiosis with Symbolic Efficacy

The very *anthropomorphic* nature of the spirit world strengthens the attunement of ritual symbolic expression to the spiritual entities themselves. This anthropomorphic epistemic response is quite ancient and is more experiential than ideological:

...there is virtually no phenomenon to which humans do not ascribe human features, either as persons or as artifacts of personal action. These features may be physical, but more importantly include theory of mind, with human linguistic and symbolic capacities; narrativity; teleology; and mind-body dualism. (Guthrie in Hodder ed., 2014:98)

Ritualized musicality has the heightened power to affect “agencies” in the experienced spirit world, thus having *efficacy* (Lewis in Arbib, 2013:53; Arom, 2004:7). Mbendjele *ekila* (Lewis in Hewlett, 2014:ch. 7; Finnegan, 2008:83) and supernatural notions about the forest and its creatures (Lewis, 2002:95) consist of anthropomorphic attributions of human qualities. The supernatural is blended seamlessly with the seen quotidian world such that named ritual song/dances address spiritual entities in a highly congruent way and the resulting ethologies become increasingly engrained via a social feedback loop.

Dance/song performance seen as an *isolate* is not symbolic but in the larger context it requires symbolic cognition for its production and perception. Musical forms address

the *displacement* inherent in an *imagined* spiritual and natural world. Musicality and ritual forms are symbiotic complements where dance/song is embodied kinesthetic memory grounding and perpetuating the metaphysics of cosmology and sacred propositions. This culturally embedded musicality is tens of thousands of years old. Susanne F rniss describes its role as the *channel* between natural and supernatural:

*Music making is an essential activity, both for the society as a whole and for the individuals that are its foundation, each **serving in their own way as intermediaries between the natural and supernatural worlds...*** (F rniss in Hewlett 2014:ch.7 [emphasis added])

... music is the very means man has to make contact with these [supernatural] forces... [Each] music may be said to correspond to a precise function, a function to which the 'liturgical' ensemble in which it is inserted corresponds. (Arom, 2004:7)

The named dance/song is the ancient ancestor of **prayer** in the Common Era. It is presumed that the dance/song projects non-verbal signals to (“theory-of-mind”) animals and spiritual figures that receive them as their semiotic *interpretants*. Hunter-gatherers are peers of the animals and spirits and act as the caretakers of “peace in the forest” whereas, with Common Era **prayer**, the supplicant is *lowly* compared with the “creator/lord” being beseeched. Tomlinson, drawing on Steven Mithen, (2015:278) argues for a cognitive symbiosis between musicality (mind/body) on one hand and religious-ritual thought on the other:

The connection of musicking to ritual, religion, metaphysics ... came about as an unfolding congruency between this musical cognition and the similar cognition that made them [religion, etc.] possible. [M]inds capable of formalized abstraction ... linked transcendentalized sociality to musicking in a dance coforming the two.

2.6 Implications for Language Evolution: Multi-Domain Mapping

Michelle Kisliuk’s monograph (2001:ch.4) on BaAka music and life tells of “Seeking the Mother of Elamba” – a “sacred” named dance widely revered. The “mother” is the source of the dance – a curator not an elevated “expert”. The polyrhythmic Elamba dance has a cognitive-kinesthetic complexity. It is loaded with nuance of body language, gesture, and timing. Kisliuk is a young musicologist-anthropologist with unique social and musical skills.

With a difficult kinesthetic structure, the Elamba dance is one half of the cognitive symbiosis discussed above in §2.5: a domain unto itself with its own techniques and semantics. The other half is the spirit world, its entities, and the spiritual access people

have to the animals. As a cognitive domain in its own right, these sacred narratives only exist as embodied and embedded in the ritual praxis of the named dance/songs. There is no verbal recitation of the “beliefs”. The two domains are intertwined. The symbiosis produces a symbolic efficacy that can soften up animals for the kill and beckon or banish quirky anthropomorphic spiritual entities. The cultural practice provides social cohesion as well as an extraordinary perseverance through tens of millennia. Brown et al (2014) have found genetic markers that correlate with this deep-time persistence.

Fifteen years ago Brown (in Wallin et al, 2000:ch.16) proposed “musilanguage” as a common ancestor for music and language (verbal speech). But since 2000, neuroscience has found that music and language are jointly parasitic on many of the very same neurobiological underpinnings (Koelsch, 2013:§13.2,§9.6) as well as riding on the precursors listed in §1.1 above. Emerging in *parallel* in the same biocultural niche (Cross et al in Arbib, 2013:ch.21), music and language were formed out of the friction of use attending to very different social needs yet were part of a single articulatory continuum. Positing a “common ancestor” only spawned more unanswerable questions. Careful critiques of this, like Botha (2009), helped get us past this. Both musical forms and verbal speech deal in different yet analogous ways with the generational issues of social memory (see §2.4 above).

The cognitive domain mapping going on in ritual dance/song is interesting because of its overlap with the generational problem humans must have faced in the Paleolithic. Lithic and related technologies gradually grew more complex. Steps increased and logistics in production and use grew in complexity. At some point it didn’t work to just do a “look at me now”. Dual domains of the embedded gestures of work and symbolic articulations about it had to be cognitively cross-correlated. Music/dance/song was recruited for spiritual matters. Referential articulation with minimal ambiguity can train the next generation about tool production and related skills. Dual-domain mapping was essential in both scenarios and implicated broadly in symbolic behavior.

For Sterelny (2012:ch.3) the generational accumulation of culture is inherently symbolic: “...the distinctive character of human social life depends on the accumulation, preservation, and intergenerational transmission of cognitive capital.” (ibid:§3.5) Tomlinson (2015:181) concurs: “Since forms of production transmitted from generation to generation in the guise of stone tools reach back to the earliest Acheulean traditions we can trace, stone tool production itself – *culture* itself – comes from its first appearance to be pervasively symbolic.” Elsewhere, Sterelny (2012a:2148) argues that “...the elaboration of skilled artisanship with the evolution of context independent and syntactically structured signals, [shows] that the skilled action–gesture co-evolutionary feedback loop helps us explain not just a general increase in communicative capacity ... [but also certain] features central to language as a communication system.”

References

- Arbib**, M.A. ed. (2013). *Language, music, and the brain: A mysterious relationship*. Cambridge, MA: MIT Press.
- Arom**, S. (2004). *African polyphony and polyrhythm*. Cambridge, UK: Cambridge University Press.
- Boehm**, C. (2001). *Hierarchy in the forest*. Cambridge, MA: Harvard University Press.
- Botha**, R. & Knight, C. (2009). *The cradle of language*. Oxford: Oxford University Press.
- Botha**, R. (2009). On musilanguage/“HmMMM” as an evolutionary precursor to language. *Language & Communication*, 29(1), 61-76.
- Botha**, R. (2016). *Language evolution: The windows approach*. Cambridge, UK: Cambridge University Press.
- Brown**, S. et al (2006). The neural basis of human dance. *Cerebral Cortex*, August 2006;16;1157-1167.
- Brown**, S. et al (2014). Correlations in the population structure of music, genes and language. *Proceedings of the Royal Society of London B: Biological Sciences* 281.1774 (2014): 20132072.
- Chen**, Y.S. et al (2000). mtDNA variation in the south african kung and khwe. *The American Journal of Human Genetics*, 66(4), 1362-1383.
- Clark**, A. (2013). Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioral and Brain Sciences* (2013) 36, 181-253.
- Corser**, C.A. et al (2012). The Q2 mitochondrial haplogroup in oceania. *PLOS ONE*, Dec. 2012. doi:10.1371/journal.pone.0052022.
- Dennell**, R. & Porr, M. eds. (2014). *Southern asia, australia and the search for human origins*. NYC: Cambridge University Press.
- Deutsch**, D. ed. (2013). *The psychology of music (cognition and perception), third edition*. London: Elsevier.
- Dor**, D., Knight, C. & Lewis, J. (2014). *The social origins of language*. Oxford: Oxford University Press.
- Enfield**, N.J. & Levinson, S.C. eds. (2006). *Roots of human sociality*. Oxford: Berg.
- Finnegan**, M. (2008). *The political is personal*. PhD dissertation, University of Edinburgh.
- Finnegan**, M. (2013). The politics of eros: ritual dialogue and egalitarianism. *Journal of the Royal Anthropological Institute*, 19(4), 697-715.
- Fisher**, L.F. & Garcia J. R. & Chang, S. (2013). *Evolution's empress*. Oxford: Oxford University Press.
- Ghazanfar**, A. A., & Takahashi, D. Y. (2014). The evolution of speech: vision, rhythm, cooperation. *Trends in cognitive sciences*, 18(10), 543-553.
- Grauer**, V.A. (2011). *Sounding the depths: Tradition and the voices of history*. CreateSpace. Audio at: <http://soundingthedepts.blogspot.com>.
- Hewlett**, B.S. ed. (2014). *Hunter gatherers of the congo basin*. New Brunswick: Transaction Publishers.

- Hodder**, I. ed. (2014). *Religion at work in a neolithic society*. Cambridge, UK: Cambridge University Press.
- Jordania**, J. (2011). *Why do people sing? Music in human evolution*. Tblisi: Logos.
- Kisliuk**, M. (2001). *Seize the dance! BaAka musical life and the ethnography of performance*. Oxford: Oxford University Press.
- Koelsch**, S. (2013). *Brain and music*. Hoboken: Wiley-Blackwell.
- Levinson**, S. C., & Holler, J. (2014). The origin of human multi-modal communication. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 369(1651), 20130302.
- Lewis**, J. (2002). *Forest hunter-gatherers and their world*. PhD thesis. Univ. of London
- McNeill**, D. (2012). *How language began: Gesture and speech in human evolution*. Cambridge, UK: Cambridge University Press.
- Mellars**, P. et al (2013). Genetic and archaeological perspectives on the initial modern human colonization of southern asia. *PNAS*, 110 (26), 10699-10704.
- Mellars**, P. et al (2013a). Supporting information for Mellars (2013). *PNAS*, 110 (26).
- Merker**, B. H., Madison, G. S., & Eckerdal, P. (2009). On the role and origin of isochrony in human rhythmic entrainment. *Cortex*, 45(1), 4-17.
- Morley**, I. (2013). *The prehistory of music*. Oxford: Oxford University Press.
- Morley**, I. (2014). A multi-disciplinary approach to the origins of music. *Journal of anthropological sciences*. 92, 147-177.
- Narvaez**, D. et al eds. (2013). *Evolution, early experience and human development*. Oxford: Oxford University Press.
- Radman**, Z. ed. (2013). *The hand, an organ of the mind*. Cambridge, MA: MIT Press.
- Royce**, A.P. (1977, 2002). *The anthropology of dance*. Hampshire: Dance Books Ltd.
- Severi**, C. (2014). Transmutating beings: A proposal for an anthropology of thought. *HAU: Journal of Ethnographic Theory*, 4(2), 41-71.
- Severi**, C. (2015). *The chimera principle: An anthropology of memory and imagination*. Malinowski Monographs: HAU.
- Shipp**, S., Adams, R.A., & Friston, K.J. (2013). Reflections on agranular architecture: predictive coding in the motor cortex. *Trends in neurosciences*, 36(12), 706-716.
- Sterelny**, K. (2012) *The evolved apprentice*. Cambridge, MA: MIT Press.
- Sterelny**, K. (2012a). Language, gesture, skill: the co-evolutionary foundations of language. *Phil Trans R Soc B* 2012 25 June 2012. doi:10.1098/rstb.2012.0116
- Tomlinson**, G. (2015). *A million years of music*. Cambridge, MA: Zone/MIT Press.
- Vuust**, P., & Witek, M.A. (2014). Rhythmic complexity and predictive coding: a novel approach to modeling rhythm and meter perception in music. *Frontiers in psychology*, 5
- Wakita**, M. (2014). Broca's area processes the hierarchical organization of the observed action. *Front. Hum. Neurosci.* 7:937. doi:10.3389/fnhum.2013.00937
- Wallin**, N.L., Merker, B. & Brown, S. (2000). *The origins of music*. Cambridge, MA: MIT Press.
- Willems**, R.M. & Hagoort, P. (2007). Neural evidence for the interplay between language, gesture, and action: A review. *Brain and Lang.* Vol. 101, No. 3, 2007.