

Chapter 2

Protomusic and Speech

2.1 The Role of Protomusic

Darwin (1859) did not discuss in his first great work “Origin of Species” evolutionary approaches to the human mind and thus avoided to argue against anti-evolutionist positions such as explicitly expressed by the linguist Friedrich Max Müller (1866). According to Müller, it is language, which is the key feature that divides man from beast. Darwin introduced the idea of a musical protolanguage, a concept that still represents an important aspect of modern debates. Comparable ideas were already expressed in the seventeenth century, to which Darwin also refers. For example, it has been argued that bird songs have some function arising from male rivalry and territorial competition (Thomas 1995). Thus, although he took a multi-component approach towards language evolution, Darwin emphasizes the significance of complex vocalization by embedding his view in a broad theory of evolution (e.g., Fitch 2000; Egnor and Hauser 2004). Darwin (1871, pp. 880) mentions in his second great work “The descent of man and selection in relation to sex” some issues related to the evolution of language: “... *it appears probable that the progenitors of man, either the males or females or both sexes, before acquiring the power of expressing their mutual love in articulate language, endeavoured to charm each other with musical notes and rhythm.*”

In particular, evolutionists and their opponents agreed that emotions and memory are shared between humans and animals. Darwin’s approach can be summarized in short as follows: First, he points out that the “language instinct” is not a true instinct but involves a learning process. By using the term “instinctive tendency to acquire an art”, he does not solely refer to a language instinct but to an instinct of any form of more complex culture and cognition. Second, Darwin already recognized that the seat of the language capacity is the human brain while the human vocal tract alone is insufficient to empower humans with language. Third, he draws a parallel between human and bird vocalization: Birds have an instinct to sing, humans have an instinct to speak (in addition to singing) and the acquisition of regional dialects is both characteristic for bird songs and human speech (see Fitch 2013). Not only these general observations can be considered still as quite contemporary as they

are even today of much debate but also his account of “musical protolanguage” to which we refer here as “protomusic.”

First, Darwin assumes that the development of cognition and social intelligence represents the foundation for the rise of protomusic and then to protolanguage (Hewes 1973; Bickerton 1990). Some salient properties of protomusic would have been driven by sexual selection, and it has been used in courtship, territorial behavior and in expressing emotions such as love, jealousy, and triumph. Darwin emphasizes in particular that vocal imitation is a cognitive function, songbirds and humans are sharing. Initial communication might have started with vocal imitations and by associating vocalizations with objects, states, events, actions or emotions, and/or properties of thereof to create meanings (Holloway 1969, 1992). Among others, the imitations may refer to onomatopoeia (e.g., imitating animal sounds, sounds of natural events or sounds expressing emotions) or even to the instinct calls of our direct ancestors supported by gestures and signs. Darwin assumed that vocalizations have been the primary trigger for the evolution of language but not gestural signals as it would have been more recently advocated (e.g., Corballis 2003; Arbib 2005; Call and Tomasello 2007). Moreover, Darwin makes the plausible assumption that along with increased vocalization the vocal tract became gradually refined allowing a broader range of discrete utterances. His approach is highly plausible as Darwin refers to comparative data: vocal learning evolved in different clades in mammals such as bats, cetaceans, pinipeds, and in birds such as oscine songbirds, hummingbirds, parrots without referring to symbolic meanings. The precise development of symbols and propositions expressing meanings at the sentence level remains highly speculative. Here, however, more complex cognition certainly played an important role in further developments of communicative skills in our early ancestors. Thereby, it is to assume that the development of social competence and strategic planning including tool use contributed to the rise of more complex language competence.

Accordingly, it remains a secret how the concept of phrases or sentences was developed either out of single words or directly out of protomusic or a combination thereof. This question is reflected in today's debate about holistic protolanguage. The linguist Otto Jespersen (1922) claimed a holistic starting point as such that propositional meanings were derived from sung phrases. (Multi-)syllables of music phrases would have been isolated and associated with individual lexical meanings referring to different syntactic categories (parts of speech). This holistic approach implying synthesis by analysis was defended in recent discussions on the origin of language (Wray 1998; Arbib 2005) but extensively criticized by accounts favoring an analysis by synthesis approach, in which syntactic operations are learned to combine single words (Bickerton 2007; Tallerman 2007). Often certain models represent extreme scenarios and a more realistic picture is provided by using plausible properties of different accounts to approach the relevant scenario. Indeed, in assuming protomusic as a starting point, an interesting hypothesis is that global or holistic meanings were expressed by vocal sequences referring to complex events. The gradual process of fractioning resulted over time in discrete tonal units and/or phrases. However, before discussing in more detail a possible scenario about the origin of proto-communication and its evolving characteristics towards language,

here we like to provide evidence for the assumption that vocalization *per se* was the starting point for the development of complex communication among humans.

2.2 Evolutionary Milestones

The primary form of communication among our closest relatives, the apes, is vocalization, whereas gestures or other non-verbal signals seem to have a supportive function. As mentioned before, other species prefer vocalization including ultrasound communication: dolphins, rodents, insects, avian, amphibian, and fish. Thus, vocalization is the primary form of social communication in a large number of different species. Thereby, initial stages of vocalization, the babbling stage, shows surprising parallels in humans, songbirds and other animals. Human infants babble spontaneously in the first year followed by different stages of language acquisition. Similarly, juvenile songbirds vocally babble by producing immature songs. For instance, baby zebra finches learn singing by listening to their tutor, typically the father. About 1 month after hatching, they babble a rapid stream of screechy tones and practice for hours. After 3 months of learning, the juvenile can exactly imitate the tutor's song. There are astonishing parallels of vocal learning and production between different species and further comparative research may inform us in more detail about the phylogenetic development of those (sub-)cortical systems supporting complex vocalization and therefore spoken language. The origin of vocalization in the history of human evolution, however, remains highly speculative, but we discuss in the following some possible scenarios without denying that alternative viewpoints are possible. Let us summarize in the following some significant milestones assumed to be involved in the evolutionary origin of modern language and which seemed to have built on each other:

Protostages

- Cognition: multi-sensory experience, instinct calls
- Music: rhythm, prosody, syllables
- Phrases: embodied concepts, basic phrases
- Speech: discrete sounds, symbolic concepts, basic syntax

The gradual increase of the cranial capacity and thus the rise of cognition might have already started as early as with the appearance of the *Australopithecus* ca. 4 million years ago (mya). It is believed that in the eastern part of Africa one of the australopith species, *Aus. sediba*, evolved about 2 mya into genus *Homo*. Thus, we claim at this point that our pre-human ancestors were generalist compared to the evolving human species. They might have used a variety of different communicative signals across different sensory-motor modalities including instinct calls, gestures, and grimaces to inform about dangers, benefits, or to express emotions. The multi-sensory interaction of various sources such as tones, noise, light, smell, tactile stimuli may have led to improved sensory-specific working memory (WM) functions, associative connections, and conceptual representations. Climate changes

and/or the attempt to discover new ecological niches in the savannah may have led to more complex cognitive processing and thus favoring the evolution of a larger cranial capacity.¹ Thus, we assume that multi-sensory integration motivated by climate changes and social planning is the primary factor for the increase of cortical structures. Further specializations were probably triggered by various factors, in particular by the emergence of improved means of communication.

The use of protomusic, that is, of melodic-rhythmic patterns and harmonic passages, might be triggered by sexual selection, as proposed by Darwin (1871), parent care and group cohesion. Sexual selection expressed in courtship is an elaborative trait, which is beneficial in the competition for mates (Miller 2000). Also, motherese—the use of melodic and rhythmic utterances for infant offspring—is an important mean to provide infant care. Finally, protomusic might have been again beneficial for promoting social cohesion within groups (Brown 2000). Although, we argue here for an adaptationist approach, it should be pointed out that there are numerous alternative views including those arguing in favor of a non-adaptationist view of music evolution. According to a non-adaptationist stance, natural selection did not drive the origin of music. A variety of claims were made arguing, for example, that music grew out of impassioned speech (Spencer 1857) or incidental peculiarity of the human brain (James 1890; see also Pinker 1997). However, according to an evolutionistic neurobiological stance, it remains a plausible hypothesis that modern music as well as modern language are the product of natural selection evolving from protomusical behavior.

While we certainly can find arguments to explain the important role of protomusical behavior, it is difficult to model a gradual specification towards language. Thereby, the evolution of gradual changes is not disputed, but questions about the cultural-behavioral influence on genes and vice versa. We assume that our distant ancestors use their vocal tract to produce a variety of different pitches and volumes, perhaps accompanied by dance steps. Moreover, it is difficult to speculate where the concept of harmony and melody comes from but the concept of timing seems to be here fundamental. Timing involves the coordination of events, to synchronize processes and is biologically rooted. Life is timing and each organism has an inner clock, which must operate according to specific sequences. This concerns every aspect of an organism from heart beats, action potentials to speech coordination. Our distant ancestors must have discovered rhythm and harmony, perhaps by listening to their own heart beat and by means of ritualized behavior. The innate capacity to perceive harmonic patterns and melodies may indeed be a reflection or an expression of the principles of mother's nature that creates life. These biological principles may have represented the foundation for mapping biological structures to cognitive behavior. We further assume that cognitive specialization took place in various domains, which resulted in a cognitive capacity today known as human intelligence.

¹ Some recent studies indicate that our distant ancestors were not forced to leave rain forest in northeast Africa because the savannah expansion replacing forest territories. In fact, it is unlikely that at any time in the last 12 million years forest was extensive in the northeast Africa (Feakins et al. 2013). Thus, it appears that our ancestors tried to adapt to new ecological niches.

Modern language can be considered as one product of this cognitive evolution. But let us further speculate how modern language evolved from protomusic.

The next stage we postulate here refers to protophrases. Here, protophrases are vocal sequences derived from protomusic, whereas prosody and intonation has been at least partly preserved. It contrast to the melodies of singing, however, protophrases represent discrete sequences or icons used to refer to objects. Our distant ancestors may have vocalized to imitate other animals and environmental sounds and/or they produced random syllabic structures to express feelings. Thus, here we assume that phrasal or syntactic patterns were already used before the creation of symbolic concepts. These protophrases may have consisted of one or more units and were iconic, synthetic, and non-holophrastic in nature. Thus, we assume in line with Bickerton (2003) that it is unnecessary to postulate phonologically complex holophrases. The proposed phrases may have included also expressions what we call today proper nouns. Even apes can differentiate between different members in a group and have an idea about kinship relations. Primarily sensory embodied, single objects may have been named.

Because of lack of evidence, dating these different stages is not possible, but we speculate here that the discovery and development of symbolic behavior may correlate with a significant increase of cortical volume. In particular, the *Homo erectus*/*Homo ergaster*, who had an increased brain size of up to 1,100 cc, is a candidate for this development as this hominid species seems to have used more elaborated social structures, much like modern humans, and used sophisticated tools occasionally found with their fossils. Thus, we postulate that protophrases were used in the next stage as discrete units in a symbolic fashion. Thereby, units referring to conceptual categories form conceptual cluster among themselves. These clusters are today known as syntactic structures, which were gradually used in a recursive fashion to form subclauses. The development of discrete units at the basic lexical and syntactic level is perhaps the stage, which is typically referred to as protolanguage. Here, we use the term protospeech as human communication was primarily vocal by using vowel-consonant clusters. It is a stage, at which language has been born, a new cognitive ability with musical properties as residuals. The remaining development towards modern language includes everything what modern languages are made of. In addition to more complex phonological and syntactic structures, constraint by memory limitations, a large conceptual lexicon was acquired and taught from generation to generation. The evolution of the language system, which is even today an ongoing process, may have reached the modern stage not before the appearance of the *Homo sapiens*. Gradually specific linguistic features were added as they turned out to be useful for expressing specific meanings. For instance, the use of closed-class elements, words, which carry meaning only in a sentence context (e.g., determiners, pronouns, conjunctions, particles), may be a product of a late stage as it may be the use of inflection and derivations or verb argument structures. Today, we know that all (possible) human languages conform to a certain set of parameters, which presumably can be mapped onto innate properties. There is a dispute about how strict the set of parameters should be, but there is no doubt that biological constraints determine the acquisition and use of modern languages in *H. sapiens*.

Label	Function	Structure	Timeline (mya)
Cognition	Multi-modality	Multi-sensory experience, instinct calls	4 Aus. sediba 2 H. erectus 0.2 H. sapiens
Protomusic	Sound imitation	Rhythm, prosody, syllables	
Protophrases	Iconic reference	Embodied concepts, basic phrases	
Protospeech	Symbolic reference	Abstract concepts, phonemes	
Language	Sentences	Complex grammatical dependencies Figurative language	

Table 2.1 Possible milestones in the evolution of modern language. Function and structure built on each other. Here it is assumed that protomusic represents the foundation for the development of language and music in *H. sapiens*. Other non-verbal routines such as gestures or dance are considered to supplement vocalization and articulation.

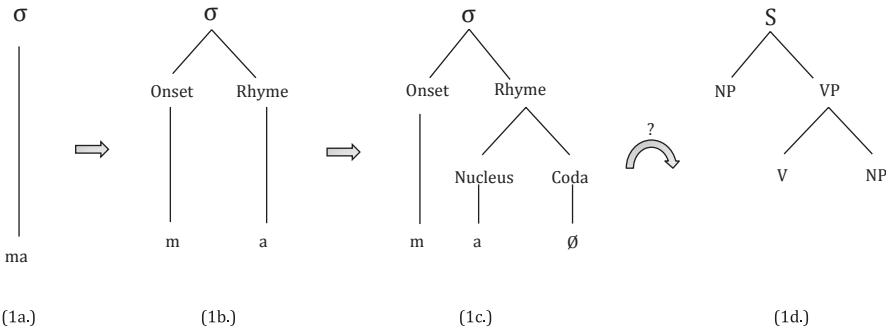
Thus, here we ask which hominid species (closer than chimpanzees) had which property of modern language as it is a product of a continuous biological and cultural evolution rather the result of a sudden mutation. Our descriptions of the different stages can be regarded as a preliminary approximation for drawing a plausible picture of the evolving human language capacity. The human language faculty is not only the result of a cultural process that modifies lexical and grammatical knowledge across many generations, but it is also a biologically adapted cognitive capacity that evolved over millions of years. Table 2.1 details the proposed evolutionary milestones described above. Certainly, we would not be surprised if these ideas attract criticism, but taking into account the spare evidence available, the selected approach seems to be at present quite plausible.

The evolution of cognition is based on processing and integrating sensory-motor experiences. The occipital-temporal-parietal connections of the cerebral cortex integrate these data. In humans, in particular Wernicke’s area is located in the tempo-ro-parietal junction, which is also responsible for speech perception and language comprehension. The planum temporale is typically larger in the left hemisphere (in particular in the case of right-handers). This left-sided asymmetry was also found for the homolog areas Tpt in chimpanzees. In macaques, area Tpt is involved in multisensory processing, but seems to play a major role in auditory processing such as discrimination of sound location (Smiley et al. 2007; Hackett et al. 2007). It is also known that area Tpt is involved in processing species-species vocalizations in chimpanzees and in Old World Monkeys (Taglialatela et al. 2009). Thus, Wernicke’s area may be an older area than Broca’s area (POp, pars opercularis; PTr, pars triangularis). Broca’s area seemed to have evolved along with the increasing complexity of grammatical dependencies and to coordinate speech and language production. It might be that *Australopithecus sedipa*, which supposed to have evolved into *H. ergaster*/*H. erectus* about 2 mya, was able to refer to individual perceivable objects

by using instinct calls. While comprehension of objects was supported by multi-sensory concept formation, the ability to communicate about these experiences presumably relied at this stage on sound imitations replacing instinct calls. The model here implies that mothers were singing to their babies by imitating sounds. Moreover, these sound imitations were successively amended by syllabic consonant-vowel (CV) patterns (e.g., *ma-ma*, *ah-ah*). These patterns were part of rhythmic melody to comfort and reassure the offspring. To what extent other forms of expressions such as gestures or dance has been used in combination with vocalization for clarifying the expressed meaning, remains an open question. However, protomusic is here the hub of the present account and we assume that syllabic combinations were used to refer to objects (e.g., *he-he ro-ro* >> danger lion). The examples here solely serve as illustrations, but do not indicate the attempt of a realistic approximation of the vocalized patterns. The next milestone protophrases involves the ability to use discrete units by using particular patterns as general iconic attributes for a variety of different objects; *he-he*, for example, could have been combined with any objects that seem to indicate danger (e.g., *he-he na-na* >> danger strangers). Although these protophrases may have their roots in protomusical patterns, their units can be considered as discrete units, which can be infinitely combined and represent basis syntactic structures. But we do not make claims that different units were systematically combined at this stage to form hierarchical syntactic structures. This function, called merge, might have been developed in its basic form during the epoch of *H. erectus*.

H. erectus, assumed to be the direct descendent of *Au. sediba*, may be the species, which began to use these syllabic combinations. Along with the development towards embodied concepts, a large set of phrases were developed stimulating an increase of working memory capacities in the prefrontal cortex. It has been discussed whether the function merge were born out of syllabic structures. Carstairs-McCarthy (1999) discusses an evolutionary model of syllable frames, which are considered as the foundation for initial syntax. Although this model faced some criticism (e.g., Tallerman 2005), still some aspects of this approach seemed to be plausible for the development of linguistic structures.

(1)



First, during the time span of ca. 1.8 million years, *H. erectus* developed this vocal communication system to label ideas. An elaborated conceptual system with abstract and symbolic meanings referring to general concepts away from the immediate sensory experience was created. One important aspect of this development refers to the ability to use discrete units not only at the linguistic level. The function merge with the outcome to generate hierarchical structures for the purpose to cluster complex computations may have been developed at the cognitive level. Thus, a plausible scenario might be that merge was not the result of syllabic computations *per se* that were then in turn mimicked for syntactic analysis, as shown in (1), but represented (and represents) an underlying cognitive ability used at different linguistic and non-linguistic levels: increase of syllabic frame complexity (1a.–c.), whereas (1c.) were mimicked by (1d.) to generate syntactic frames. Thus, we assume here that *H. erectus* used protospeech to communicate. As the phrases presumably did not consist of more than three discrete units, as described in more detail below, the scope of syntactic computations were limited compared to modern language. However, there are no reasons to assume that the number of discrete lexical units was somehow restricted. While the syllabic frame account might be a plausible scenario, it does not make any assumptions about the neurocognitive changes associated with the development of word order processing (linguistic syntax). Broca's area and associated subcortical structures are primarily involved in linguistic syntax as we discuss otherwise in more detail. Most interesting, Broca's area is also involved in processing music syntax at different timescales (Patel 2003). In ancient history of primates, before the development of protospeech and modern language, Broca's area may have its genetic roots in efficient computations of motor sequences. It is not only connected with parietal-temporal-occipital regions but also with the subcortical structure such as the reward circuits to express meanings. In the case of music, studies indicate that the auditory sensory cortices collaborate with mesolimbic regions (in particular with the nucleus accumbens, NAcc) to generate a rewarding stimulus. Highly desirable items produce an enhanced NAcc connectivity with the regions of the inferior frontal gyrus (IFG). Based on a diffusion-weighted imaging (DWI) fiber tracking method, direct *in vivo* evidence for a structural connectivity between Broca's area and the basal ganglia/thalamus was recently reported (Ford et al. 2013; Salimpoor et al. 2013). The NAcc, the reward system, is part of the basal ganglia and if a pleasure sensation is generated in context of tasty food, love, win, or pleasant music, just to name a few examples, more dopamine will be released into the ventral tegmental area, NAcc and the prefrontal cortex. Thus, the neural circuits connecting the basal ganglia with the prefrontal cortex, including Broca's area, is an important functional interface for enjoying and computing music in modern humans. Moreover, Broca's aphasic patients, who primarily suffer from syntactic processing deficits, usually do not have only lesions in Broca's area but the lesions involve also subcortical structures. Thus, lesions to Broca's area alone do not cause Broca's aphasia, but the neural circuits associated with Broca's area. While we do not discuss here the shared or common neural resources of music and language, we assert that music and linguistic phrasing recruit the same neural circuits.

Similar to the evolution from *H. erectus* to *H. sapiens*, the evolution from protospeech to modern language occurred gradually, at least there is no plausible reason

to assume otherwise. Among other significant changes, an increase of working memory span in the prefrontal cortex is one important condition for processing more complex linguistic syntax that involves non-canonical sentence structures or long-distance dependencies. At the same, sub-lexical processing continued to evolve towards lexical morphology to mark different meanings. Today's modern languages using the following morphological structures, which all were presumably not components of protospeech: affixes (e.g., Case, Gender, Number, Time), lexical derivations (e.g., word class changes: verb to noun), irregular verbs (e.g., separate lexical entry instead of using a past tense rule for regular verbs), contrast between function words (typically: determiners, pronouns, conjunctions, pre- and postpositions), and content words (typically: nouns, verbs, adjectives, adverbs). Furthermore, the ability of figurative speech evolved reflected in various different types such as metaphors, fixed phrases (including idioms), puns, humor, irony, neologism, hyperboles, satire, etc.

Simultaneously, protomusic evolved to modern music abilities and it is to assume that other *H. sapiens*' specific cognitive capacities such as fine motor control of hands and feet evolved to those abilities we use today on a daily basis. The literature about a connection between language processing and the reward system is virtually non-existent, but this thematic niche may require experimental studies. Successful communication as any other cognitive computation is certainly rewarding and is *inter alia* an emotive act, in particular if the dialog partner responds as desired. Our ancient reward and motivational system may provide the answer on how original harmonic sound patterns gradually transformed to the first linguistic computations.

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