Without breath and without song?

W. Tecumseh Fitch's recent review of the evolution of human vocalization overlooks two key issues: breathing and song[1]. Following Philip Lieberman[2], Fitch links the inability of non-human primates to make speech-like vocalizations to the lack of the human lowered larynx and the wide range of vowel sounds that that makes possible. This is doubly amiss. First, human languages exist (in the Arandic group in Central Australia) that do not exploit the phonetic range made possible by the lowered larynx (they only use two rather similar vowels). As Ian Maddieson, who notes this fact, observes (I. Maddieson, 1998, Vowel systems and language origins, 2nd Int. Conf. Evol. Lang. Abstracts), 'the question of the capability or otherwise of the hominid vocal tract to produce vowels like /i, a, u/ has no obvious relevance to determining how language might have developed'. (A similar point has also been made by Charles Hockett, Ref. 3, pp. 294–295.)

Second, Fitch ignores the fact that humans alone among primates combine the ability to make prolonged out-breaths while coordinating subglottal pressure from the lungs with vocal tract articulations. Without such breath control, multiple strings of vocalizations cannot be sequenced together to form spoken words. This specialized vocalization–respiration – known as 'thoracic breathing' – is anatomically and neurologically separate from 'quiet breathing', the respiration by which we and other animals acquire oxygen and clear carbon dioxide. Anatomically, quiet breathing normally uses the diaphragm; thoracic breathing, by contrast, uses the intercostal and abdominal muscles. Neurologically, in humans, the use of these muscles for vocalization has led to expansion in the thoracic region of the spinal cord (the diaphragm is innervated by a separate and cranial source, the vagus nerve). As Fitch notes, MacLarnon and Hewitt[4] have analysed thoracic vertebral canal measurements in various primate species and showed that this spinal cord expansion (which can be seen in surviving fossil vertebra) dates to after 1 600 000 BP (it is absent in the vertebra of the Nariokotome skeleton KNM-WT 15000) but before 100 000 BP (when it is first found). Running and over-arm throwing cannot explain such spinal cord expansion because the postcranial remains of the Nariokotome skeleton show the full biomechanical adaptation found in modern *Homo sapiens sapiens* for throwing and distance running but without such enlargement[4].

Thoracic breathing and the lowered larynx makes our vocal tract an exquisite musical instrument – a fact not mentioned by Fitch. Although song lacks the obvious utility of speech, song could have had earlier advantages, which were later taken over by speech. It is indeed plausible that human vocalization initially evolved for song rather than speech[5,6]. Song and speech both use similar methods of breathing[7] and their production and initiation in the brain both depend upon the left hemisphere[8] (even though many aspects of song such as pitch and tonality are more probably right hemisphere functions).

The usefulness of song has led to its independent evolution in diverse animals including birds, sea mammals and, on four separate occasions, by non-human primates – indris, titis, tarsiers and gibbons[9]. One advantage of song is that it provides a powerful means for parents to form and maintain bonds[10], something selected for when the resource demands of offspring exceed those that can be provided by a single parent. Human brain expansion created infants with greatly increased needs for resources, an extra demand fulfilled by humans forming parent bonds. In modern humans, these bonds depend upon speech-based cultural and symbolic commitments. An important problem in human evolution is what enabled humans to bond before them. In the four primates other than our species (indris, titis, tarsiers and gibbons) that are obligatory reproductive pair-bonders such bonding is done through song[10]. Contemporary humans are known in non-parent contexts to bond emotionally with the aid of song (in such activities as anthems, hymns, work and marching songs and stadium chants[11]). Parsimony suggests that early humans solved the pre-speech parent-bonding problem in the same way as other primates – with song. Such early evolved song would have provided the vocalization adaptations that then enabled the evolution of speech.

This idea is supported by internal evidence about how we learn speech. Speech is a complex skill that requires subskills in order to develop. If song had existed before speech, speech would have incorporated song as a key subskill in its development. I suggest that this is the case: prosody (the song element in speech whose processing arises at an earlier age than speech) plays a critical role in aiding prelinguistic infants to perceptually segment words out of the speech stream[12], and to identify clause boundaries needed to learn syntax[13]. This suggests that without the earlier existence of song, speech could not have arisen.

These issues – breathing and song – are not minor ones but at the very centre of the problem of modelling the relevant adaptations that now enable us to speak. It is a disappointment that Fitch failed to review and discuss them.

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References

1 Fitch, W.T. (2000) The evolution of speech: a comparative review. *Trends Cognit. Sci.* 4, 258–267

2 Lieberman, P. (1998) *Eve Spoke: Human Language and Human Evolution*, Norton

3 Hockett, C. (1978) In search of Jove's brow. *Am. Speech* 53, 243–315

4 MacLarnon, A. and Hewitt, G. (1999) The evolution of human speech: the role of enhanced breathing control. *Am. J. Phys. Anthropol.* 109, 341–363

5 Richman, B. (1993) On the evolution of speech: singing as the middle term. *Curr. Anthropol.* 34, 721–722

6 Vaneechoutte, M. and Skoyles, J.R. (1998) The memetic origin of language: modern humans as musical primates. *J. Memetics* 2: http://www.cpm.mmu.ac.uk/jom–emit/1998/vol2/vaneechoutte_m&skoyles_jr.html

7 Hixon, J. *et al.* (1987) *Respiration Function in Speech and Song*, Taylor & Francis

8 Borchgrevink, H.M. (1991) Prosody, musical rhythm, tone pitch and response initiation during amytal hemisphere anaesthesia. In *Music, Language, Speech and Brain* (Sundberg, Nord, L. and Carlson, R., eds), pp. 327–343, Macmillan

9 Haimoff, E.H. (1986) Convergence in the duetting of monogamous old world primates. *J. Hum. Evol.* 15, 51–59

10 Wicker, W. (1980) Vocal dueting and the pair bond: 1. Coyness and partner commitment. *Z. Tierpsychol.* 52, 201–209

11 Bowra, C.M. (1962) *Primitive Song*, Weidenfeld & Nicolson

12 Sansavini, A. (1997) Neonatal perception of the rhythmical structure of speech. *Early Dev. Parent.* 6, 3–13

13 Morgan, J.L. and Demuth, K. (1996) *Signal to Syntax*, Erlbaum

Reply to Skoyles

I have always found appealing the idea that music and song provided preadaptations for language and speech. Like language, music is a human universal; it is culturally transmitted and possesses highly complex structure. Unlike language, music rarely conveys overt meaning or exact semantic reference. Music and song thus provide a plausible evolutionary bridge from primate calls to semantic language. This idea goes back at least to Darwin, who cited singing as the most likely preadaptive basis for speech[1]. Unfortunately, despite

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the periodic rediscovery of the singing hypothesis by various scholars, little convincing evidence has appeared to support it. Hence, I omitted discussion of singing in my review, which focused on empirical data. Does John Skoyles' letter[2] provide new evidence for the singing hypothesis?

Skoyles' argument relies heavily on a putatively perfect correlation between 'singing' and pair bonding in primates. Defining primate 'song' is one problem. In birds, 'song' traditionally refers to seasonal vocalizations used to defend territories and attract mates, typically by males. This definition is also applicable to the learned 'song' vocalizations of seals and whales. Singing so defined is not limited to monogamous species in any of these groups. For primates, Skoyles offers no definition and inaccurately cites Haimoff's data on duetting[3] (in which males and females sing closely interlocking vocal parts) as regarding 'singing' in general. Skoyles' short list of singers inexplicably omits langurs, an additional duetting species described by Haimoff. Skoyles' list of pair-bonding primates is procrustean, omitting the 20 species of marmosets and tamarins that show strong pair bonding and male parental care[4]. Although to some ears the chatters, trills and whistles typical of these species are musical, they are apparently not 'song' by Skoyles' criteria. Nor are the attractive coos of macaques, or the rhythmic pant-hoots of chimpanzees, both of which are exchanged in bouts – in highly polygamous species. One is left wondering how exactly Skoyles defines primate 'song' or 'pair bonding', but the supposed correlation between these behaviors is clearly based on incomplete data.

The link between singing and monogamy in humans is equally unclear. That modern human groups bond emotionally through music and dance seems reasonably obvious, but it does not follow that our ancestors evolved song to maintain monogamous pair bonds. Many theorists suppose that human monogamy (such as it is) relies on frequent sexual intercourse, inspired by the fertility-concealing adaptations evolved by human females (reviewed in Ref. 5). Few of the married couples I know reinforce their pair bond by bursting into spontaneous duets. In my experience, love songs tend to precede mating and drop off rather rapidly afterward. Darwin's suggested function for song thus seems more likely: 'that musical tones and rhythm were used by the half-human progenitors of man, during the season of courtship' (Ref. 1, p. 336). But debating this matter would be fruitless and tiresome given the lack of relevant empirical data.

Regarding breathing, our understanding of respiration and vocalization in nonhuman mammals is far too sparse to support sweeping statements about human uniqueness, and what comparative data are available cast doubt upon Skoyles' claims. All mammals (and most reptiles) have intercostal muscles and use them for thoracic breathing[6,7]. Rodents, bats, birds and macaques all have sophisticated expiratory control tightly synchronized with phonation and articulatory movements[8–10]. As usual, more comparative research is needed, and MacLarnon and Hewitt's excellent work[11] is an important step forward. But Skoyles' unjustified claims about the uniqueness of human thoracic breathing, and its link to singing, clearly illustrate the danger of basing hypotheses about human evolution on fossils in the absence of good comparative data.

Finally, concerning vowels, comparative linguists have long agreed that virtually all human languages have at least three vowels. In the more than 200 languages studied by Crothers[12], or the 317 sampled by Maddieson[13], every one has at least three vowels (overwhelmingly /i a u/). This three-vowel minimum is as close to a universal as one can find in language. Whether a few scattered languages (e.g. Kabardian) have fewer vowels is a long-argued question, but is immaterial to Skoyles' point, as their existence would not demonstrate the irrelevance of vocal anatomy to phonetic range. Clearly a few individuals' disuse of some evolved trait is no indication of its utility. By identical logic one might claim that the existence of flightless birds with wings (e.g. ostriches or wekas) demonstrates the irrelevance of wings to flight. Although the importance of human larynx position is sometimes overemphasized (see Ref. 14), its relevance to vowel production is firmly grounded in acoustics and physiology and is one of the few solid facts available to theorists interested in the evolution of speech[15].

In summary, the hypothesis that singing paved the way for speech remains as tantalizing, and unproven, as before. I sincerely hope that Skoyles will continue to work on the problem and publish some useful new data, and I look forward to citing him when he does.

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References

1 Darwin, C. (1871) *The Descent of Man and Selection in Relation to Sex*, John Murray
2 Skoyles, J. (2000) Without breath and without song? *Trends Cognit. Sci.* 4, 365–366
3 Haimoff, E.H. (1986) Convergence in the duetting of monogamous Old World primates. *J. Hum. Evol*. 15, 51–59
4 Napier, J.R. and Napier, P.H. (1985) *The Natural History of the Primates*, MIT Press
5 Diamond, J. (1992) *The Third Chimpanzee*, Harper Collins
6 Hildebrand, M. (1974) *Analysis of Vertebrate Structure* (1st edn), John Wiley & Sons
7 Troyer, A. and Estenne, M. (1988) Functional anatomy of the respiratory muscles. *Clin. Chest Med*. 9, 175–193
8 Roberts, L.H. (1972) Correlation of respiration and ultrasound production in rodents and bats. *J. Zool*. 168, 439–449
9 Hartley, R.S. and Suthers, R.A. (1989) Airflow and pressure during canary song: direct evidence for mini-breaths. *J. Comp. Physiol. Ser. A* 165, 15–26
10 Hauser, M.D. *et al*. (1993) The role of articulation in the production of rhesus monkey (*Macaca mulatta*) vocalizations. *Anim. Behav*. 45, 423–433
11 MacLarnon, A. and Hewitt G. (1999) The evolution of human speech: the role of enhanced breathing control. *Am. J. Phys. Anthropol*. 109, 341–363
12 Crothers, J. (1978) Typology and universals of vowel systems. In *Universals of Human Language* (Greenberg, J.H. *et al*., eds), pp. 93–152, Stanford University Press
13 Maddieson, I. (1984) *Patterns of Sounds*, Cambridge University Press
14 Fitch, W.T. (2000) The phonetic potential of non-human vocal tracts: comparative cineradiographic observations of vocalizing animals. *Phonetica* 57, 205–218
15 Hauser, M.D. (1996) *The Evolution of Communication*, MIT Press

Letters to the Editor

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