What phonetics has to say about Neanderthal (*H. neanderthalensis*) speech capacities

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Neanderthals likely possessed some form of language, though it is uncertain whether their vocal anatomy allowed for the full range of modern human speech sounds. We synthesize literature on estimating Neanderthal speech capabilities and conclude that evidence supports the view that Neanderthals had restricted articulatory capacities compared to modern humans due to the shapes of their vocal tracts. To date, only two estimates of Neanderthal vocal tracts remain unrefuted – and both support the view that Neanderthals were limited with regards to the range of available speech sounds.

1. Introduction

In recent years, the prevailing view of Neanderthal linguistic abilities has shifted from a doltish species to beings with complex cognitive capacities (Dediu & Levinson, 2013). As summarized by Johansson (2015, p. 311), “from the consilience of evidence from anatomy, archeology, and DNA, one can conclude that some language abilities, if not necessarily full modern syntactic language, were present in Neanderthals.” Here, we evaluate the contributions from phonetics-based approaches and estimates of Neanderthal speech capacities. The first widely discussed attempt to quantify Neanderthal phonetic capacities was performed by Lieberman and Crelin (1971), who suggested that Neanderthals were limited with regards to human-like speech production. Their findings are taken here as a baseline against which we evaluate more recent evidence arguing for, and against, the hypothesis that Neanderthals were “limited” from producing the full range of human speech sounds.

2. Basics of an evolutionary speech acoustics

In speech, the voice "source" from the vocal folds of the larynx is "filtered" in the supralaryngeal vocal tract (SVT) by the imposition of narrow constrictions using the various articulators, including the jaw, lips, velum, palate, and tongue (Fant, 1960). Because essential features of vocal anatomy are largely preserved across mammals, such fundamentals of speech acoustics have served as starting points for literature on the evolution of speech capacities (Negus, 1949; Lieberman et al., 1969, 1972; de Boer & Fitch, 2010; Fitch et al., 2016; Ekström & Edlund, 2023). The variable most crucial to the extent of the uniquely human range of speech sounds is the shape and position of the tongue inside the SVT, and the shape of the SVT itself (Lieberman et al., 1972; Carré et al., 1995; de Boer, 2010; de Boer & Fitch, 2010). In adult humans, the tongue root is descended into the pharynx, and the tongue, rounded in shape, is positioned in both the pharyngeal and oral cavities. The tongues of human infants and nonhuman mammals are flat in shape and contained almost wholly in the oral cavity (Negus, 1949). Resulting from disparate positions, while the principal musculature of the tongue is preserved across primates, innervation of equivalent musculature results in different vector forces in humans versus non-human primates (de Boer & Fitch, 2010). Resulting from a shortening of the face, and descent of the tongue root and concomitant descent of the larynx, the pharynx is markedly expanded in modern humans, resulting in roughly equal proportions between horizontal and vertical sections of the vocal tract (SVTh, SVTv). In chimpanzees, the SVTh is more than twice the length of the SVTv (Nishimura, 2005). Uniquely human proportions are optimal for generating a greatest-possible range of vowels (Carré et al., 1995; de Boer, 2010), allowing exploitation of the full range of speech sounds (Stevens, 1972). In particular, "point" vowels [a], [i], and [u] (the vowels in "ma", "see", and "do") exhibit remarkable acoustic stability. For example, these vowels are uniquely recognizable even at high pitches (Friedrichs, 2017). Accordingly, the ability to articulate these speech sounds has received significant attention in relevant literature, with Lieberman and colleagues (1972) arguing that a uniquely human capacity to articulate these vowels reflected an evolutionary pressure for improved speech communication.

3. Estimates to date

3.1. The Negus–Keith estimates

To our knowledge, anatomist Victor Negus and anthropologist Arthur Keith were the first to attempt a reconstruction of Neanderthal supralaryngeal airways

(Negus, 1949). The authors concluded that the shapes of the Neanderthal tongue and pharynx would have been closer to those of the chimpanzee and human newborn than that of the adult modern human; this would imply support for the "limited Neanderthal" hypothesis. Unfortunately, these efforts are not sufficiently described in detail to allow for replication and will not be considered further here.

3.2. The Lieberman-Crelin estimates

The first modern estimates of Neanderthal speech capacities were performed by Lieberman and Crelin (1971) and Lieberman et al., (1972). These early efforts assumed that basicranial flexion provided a reliable indicator of the shape of vocal tracts. Specifically, Lieberman and colleagues argued that non-human primates, following from possessing short and narrow pharynges and flat-shaped tongues contained in the oral cavity, were effectively incapable of imposing the degrees of stricture necessary to achieve vowels [a], [i] and [u], which are all characterized by abrupt 10:1 discontinuities at the SVT midpoint, where SVTh and SVTv meet (Lieberman et al., 1972). Boë et al. (2002, p. 465–66) have incorrectly claimed the conclusions of the Lieberman/Crelin efforts were that Neanderthals "could not speak" and that an "increase in pharynx size [was a] necessary evolutionary preadaptation for speech". Rather, the Lieberman and Crelin estimates suggested that Neanderthal phonetic capacities, limited by a short and narrow pharynx, were less extensive than those of modern humans, with a vowel space that did not include the full extent of modern human vowels – but did include vowels [ɪ], [æ], and [ɛ] (the vowels in "bit", "cat" and "bed"). Results supported the view that Neanderthals may have been unable to articulate the full range of human speech sounds have since been a focal point in subsequent debate on Neanderthal speech capacities.

3.3. The Crelin estimates

Crelin (1987) extended the efforts begun by Lieberman and Crelin (1971) to various extinct hominids (see review in Ekström & Edlund, 2023). Also based on the "basicranial" assumption, Crelin determined that skulls of both australopiths and *H. habilis* were "apelike", while those of *H. erectus* were intermediate in form. Finally, based on a reconstruction of the "Steinheim skull" (an archaic human estimated to ~250–350 kya) that the species' vocal tract had been identical to that of a present-day *Homo sapiens* skull. The exact implications are somewhat ambiguous, as the taxonomic designation of the Steinheim skull individual has been subject to disagreement (see Stringer, 2016). It is, however, now generally considered an early Neanderthal lineage hominin. Accordingly, these later Crelin estimates would provide counterevidence against the early Lieberman and Crelin attempts, and against the "limited Neanderthal" hypothesis. However, more recent developments seemingly invalidate these earlier efforts.

3.4. A twist in the tale: The changing role of the basicranium

Efforts of Lieberman et al. (1972) and Crelin (1987) assumed that flexion of the skull base provided clues to the shape of species' vocal tracts. Human infants are born with "monkey vocal tracts" and basicranial angles, and achieve uniquely human proportions only later in life, once tongue root and larynx are sufficiently descended. Evidence emerging in the late 1990's showed that the tongue root and larynx of developing humans continue to descend even *after* cranial flexure has stabilized (Lieberman & McCarthy, 1999; Fitch & Giedd, 1999). These developments, thus, invalidate the assumption upon which earlier estimates were based. The marked flexion of the skull base does not provide the information necessary for determining the shapes of vocal tracts. This finding rendered the contribution of estimates based on this assumption ambiguous.

3.5. The Boë series

The Boë estimates are the only phonetics-based work to conclude that Neanderthals were "not morphologically handicapped for speech" (Boë et al., 1999, 2002). Several methodological constraints make this determination problematic, however. The Boë series are the only estimates to base their work on the "basicranial flexure" assumption that were published after the publication of results that invalidate it. Paradoxically, Boë et al. cite Lieberman and McCarthy (1999), who invalidate the assumptions upon which their work is based. More significantly, however, the algorithm employed by the authors preserves the tongue shapes of the modern humans upon which those shapes were based – in the words of de Boer and Fitch (2010, p. 42), "precisely the aspect of the anatomy that is in question" (see also Lieberman, 2007, 2012). The same method would show that any animal would possess the full range of human speech: accordingly, the Boë series cannot be taken as evidence that Neanderthals were not "handicapped for speech".

3.6. The Barney estimates

Barney et al. (2012) provide a novel estimation method and attempt to qualify speech capacities in fossil specimens. The authors present a case study based on the (relatively recent) "La Ferrassie" skull (dated to ~50kya), and report a range of possible values, including displacement of both jaw and hyoid from anatomically predicted locations; however, neither resultant vowel space extends to that of their modern human referent. While the authors do not present a systematic exploration of results of the method as applied to other Neanderthal specimens, the study provides support for the “limited Neanderthal” hypothesis.

3.7. The McCarthy series

The most exhaustive series of estimates to date were performed by McCarthy (Lieberman & McCarthy, 2007; Lieberman, 2007, 2012) (Table 1). Namely, it is in theory possible to estimate a position for the hyolaryngeal complex, necessary for achieving a “roughly equal” SVTh-SVTv relationship (presumed necessary for the full extent of human vowel space) at resting state conditions. The McCarthy estimates indicated that, in order to achieve roughly 1:1 SVTh–SVTv proportions, the larynx of Neanderthals, reflecting a combination of short necks and long faces, would have to be placed inside the thorax – an “impossible” configuration that is not found in any extant primate: “the short neck and long Neanderthal SVTh would place the cricoid cartilage behind the sternum, permitting human speech but precluding eating” (Lieberman, 2007, p. 47). Neanderthals would, accordingly, be unable to produce “fully modern” speech.

Table 1. Summary of results of estimates.

Effort	*Neanderthals limited?*	*Refuted?*	*Source of refutation*
Negus reconstruction	*YES*	N/A	*Insufficiently described*
Lieberman/Crelin estimates	*YES*	*YES*	*McCarthy and Lieberman (1999); Fitch and Giedd (1999)*
Crelin series	*NO*	*YES*	*McCarthy and Lieberman (1999); Fitch and Giedd (1999)*
Boë series	*NO*	*YES*	*de Boer and Fitch (2010)*
Barney estimate	*YES*	*NO*	N/A
McCarthy series	*YES*	*NO*	N/A

4. What the hyoid cannot tell us about speech

On various occasions, the shape of Neanderthal hyoid bones has been claimed to be indicative of speech capacities. For example, Frayer (2017, p. 236) claims a hyoid enables "a full appreciation of the modern language capacities of Neanderthals." This argument is, however, inconsistent with the science of speech production, and does not recognize that the crucial variable for phonetic capacities is the shape of the SVT. Quoting Lieberman (1999, p. 175): "An isolated Neanderthal hyoid bone can't tell you whether the Neandertal had a human vocal tract, because the hyoid bone and larynx descend as children mature, without any systematic change in shape." Hyoid shape alone, thus, does not inform researchers of phonetic range available to extinct hominids. Any relationship between hyoid and phonetic capacities relies on soft tissue reconstruction (McCarthy & Lieberman, 2007; Barney et al., 2012). For the claim, "We now know that… the Neanderthal vocal tract is capable of producing vowels very similar or identical to modern Europeans", Frayer (2017, p. 235) cites the Barney estimates (which indicate the opposite), and work by Dediu and Levinson (2013) who base their arguments to this effect on the refuted Boë estimates.

5. What hearing cannot tell us about speech

Conde-Valverde et al. (2021, p. 609) argue, based on reconstructions of Neanderthal auditory anatomy and the assumption that "the occupied bandwidth [computed based sound power transmission] is directly related to the efficiency of the vocal communication", that "Neanderthals and Homo sapiens had similar auditory and speech capacities." The authors do not, however, provide any evidence directly bearing on vocal anatomy. In addition, novel evidence suggests that auditory thresholds emerged prior to the human-chimpanzee split (Stoessel et al., 2023). The contribution toward supporting or refuting the "limited Neanderthal" hypothesis is thus uncertain.

6. Conclusions

We have synthesized decades of work informed by acoustic phonetics bearing on Neanderthal speech capacities. To date, only one estimate (Boë et al., 1999) has concluded that Neanderthals were "not morphologically handicapped for speech" – and this work has been firmly refuted (de Boer & Fitch, 2010). Other evidence purported to indicate speech capacities – the shape of Neanderthal hyoids and inferred auditory capacities – are not useful for this purpose. The history of hominin vocal tract estimates is clouded with novel findings invalidating earlier work, and future efforts may reveal as-yet unknown relationships bearing on vocal tract shapes of extinct hominids. Currently, however, available speech acoustics research supports the view that, while Neanderthals likely possessed language, they may have been limited to a less extensive range of speech sounds.

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