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On the antiquity of language: the reinterpretation of Neandertal linguistic capacities and its consequences

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Abstract: [**1,350 characters**] It is usually assumed that modern language is a recent phenomenon, coinciding with the emergence of modern humans themselves. Many assume as well that this is the result of a single, sudden mutation giving rise to the full “modern package”. However, we argue here that recognizably modern language is likely an ancient feature of our genus pre-dating at least the common ancestor of modern humans and Neandertals about half a million years ago. To this end, we adduce a broad range of evidence from linguistics, genetics, palaeontology and archaeology clearly suggesting that Neandertals shared with us something like modern speech and language. This reassessment of the antiquity of modern language, from the usually quoted 50,000-100,000 years to half a million years, has profound consequences for our understanding of our own evolution in general and especially for the sciences of speech and language. As such, it argues against a saltationist scenario for the evolution of language, and towards a gradual process of culture-gene co-evolution extending to the present day. Another consequence is that the present-day linguistic diversity might better reflect the properties of the design space for language and not just the vagaries of history, and could also contain traces of the languages spoken by other human forms such as the Neandertals.

Keywords: [**4**] *Language evolution, Human evolution, Language contact, Genetic admixture.*

1 1. Introduction

2

3 This paper argues for a much greater antiquity of human language than has normally been assumed
4 in the language sciences. Why should researchers in the language sciences care what happened in
5 deep prehistory? We argue here that it makes a substantial difference to how we think about
6 language within the different disciplines that study it. We believe that the recognition that modern
7 language has such a relatively deep antiquity ought to have the same impact on the language
8 sciences that Charles Lyell's (1830) demonstration of the antiquity of geological process had on
9 geology, paleontology and evolutionary theory. For example, it changes how we conceive of the
10 biological basis for language, as a matter of the rather slow adaptation of multiple factors rather
11 than as a saltational mutation in one or a few genes. It might also make a difference to how we
12 think about the cultural evolution of linguistic diversity, allowing that it was slowly generated in
13 distinct areas of the Old World followed by cross-fertilization. And just as Lyell insisted on the
14 uniformitarian principle, whereby causal factors operative in deep time must be assumed to be
15 currently ongoing, so linguistic and cognitive evolution must still be underway, which has a
16 potentially profound impact on how we think about language (Levinson 2012).

17

18 In this paper we briefly review several recent lines of evidence concerning Neandertal language and
19 speech capacity, aiming to dispel the idea – still held in some influential circles – that the
20 Neandertals were an inarticulate not quite human species, arguing instead that they were probably
21 not very different biologically or cognitively from us, and that their linguistic capacities were
22 closely similar to our own.¹ We propose that essentially modern language is phylogenetically quite
23 old, being already present in the common ancestor of these two lineages about half a million years
24 ago (that is, five to ten times older than is often assumed). The evidence is necessarily
25 circumstantial, but collectively convincing we believe. Moreover, we suggest that present-day
26 linguistic diversity might have been shaped by interactions with such archaic humans during
27 modern human expansions across the world. We end by sketching the consequences of our
28 proposals for language and propose a set of predictions and methods for testing them.

29

30 Several proposals about language origins make the assumption that modern language is relatively
31 recent, arising circa 50-100,000 years ago (e.g., Bickerton, 1990, 2002; Chomsky, 2010, 2012;
32 Mithen, 2005, Berwick et al 2013). Several lines of evidence have been thought to suggest that
33 Neandertals lacked language as we know it, using instead perhaps some form of protolanguage.
34 First, general anatomical differences were suggestive of considerable evolutionary distance from
35 modern humans, with Neandertal robustness taken to imply strength compensating for restricted
36 intelligence. Second, early efforts to extract and analyze ancient DNA focused on mitochondrial
37 DNA and seemed to point to significant differences between the modern and Neandertal genomes,
38 suggesting they were a different species. Third, the recovery of parts of the fossil vocal tract and
39 auditory system was taken to suggest important differences between Neandertal and modern human
40 speech capacities. Fourth, there seems to be a large gap between the cultural products of
41 Neandertals and their contemporaneous modern humans that might be accounted for in terms of a
42 linguistic deficit. Putting these sources of information together has suggested to many influential
43 observers (such as Noam Chomsky, Derek Bickerton and Philip Lieberman) that Neandertals lacked
44 the specialized speech machinery, the higher language adaptations that would have gone with it, and

¹ Consequently, we use the term 'human' to include the sister lineages (Neandertals and Denisovans) modern humans interbred with; see below for discussion of the species concepts involved.

1 the general cognitive flexibility (e.g. recursive thought) to make good use of language.

2
3 The suggestion has consequently been that Neandertal language, if any, had properties far too
4 primitive to lie within the range of modern human languages. As a recent example, Chomsky
5 (2010:58-9) reads the evidence to show that “roughly 100,000+ years ago, the first question [why
6 are there any languages at all? DD&SCL] did not arise, because there were no languages” and
7 therefore that in our species alone “a rewiring of the brain took place in some individual, call him
8 Prometheus, yielding the operation of unbounded Merge, applying to concepts with intricate (and
9 little understood) properties...”.

10
11 However, we believe that the currently available data is more consistent with a gradualist scenario,
12 where the accumulation of small changes (both genetic and cultural) across deep evolutionary time
13 has resulted in language and speech as we know them. Before the last common ancestor of modern
14 humans and Neandertals, this evolutionary process may already have resulted in forms of language
15 and speech very similar to what we presently witness, but evolution did not stop there. On both
16 human lineages changes have continued to accumulate resulting in the modern form of language we
17 possess today on the one hand, and something else – about which we can only speculate but which
18 was most probably not too different – in Neandertals. To clarify: here, we understand language as
19 the full suite of abilities to map sound to meaning, including the infrastructure that supports it
20 (vocal anatomy, neurocognition, ethology of communication) – FLB or ‘faculty of language broad’
21 in the sense of Hauser, Chomsky & Fitch 2002.² Our proposals are neutral to any special role for
22 FLN (‘faculty of language narrow’) or a specifically syntactic unification ability, but (unlike Hauser
23 et al.) we believe many detailed features of FLB are in fact unique to humans and evolved over this
24 great timescale. Thus we attribute to Neandertals modern speech, double-articulation (separated
25 phonology and lexicon), some systematic means of word combination (syntax), a correlated
26 mapping to meaning, and usage principles (pragmatics).

27
28 Before we proceed we must warn that the literature we attempt to review crosses many fields and is
29 complex, and moreover in continuous flux with the result that there are very few points of full
30 consensus. Readers should understand that this is highly contested terrain, where each data point
31 gives rise to conflicting interpretations, and we have restricted space here. Thus, we do not attempt
32 to offer a comprehensive review but rather aim to highlight those aspects which are either little
33 known to those in the language sciences, rather new, or that have been relatively neglected in
34 discussions of language evolution, and which all favor the proposal of a greater antiquity for
35 language. Nevertheless, we also try to mention alternative interpretations and conflicting evidence
36 where feasible.

38 **2. The similarities and differences between Neandertals and modern humans**

40 **2.1 The evolutionary context**

41
42 The dominant current story (e.g., Klein 2009) in a simplified form is that, following a split about 6
43 million years ago (mya) from our nearest living cousins the chimps, a stone tool making hominid,
44 *Homo habilis*, had evolved in East Africa by about 2.4 mya. By 1.8 mya, a more advanced
45 presumed descendant, *Homo erectus*, is attested also in East Africa, a species that developed the

² For discussion of unclarities concerning the distinction FLN vs. FLB see e.g. Jackendoff & Pinker (2005).

1 distinctive bifacial hand axe (Mode 2 tools), and that dispersed relatively rapidly across the Old
2 World, from England to Georgia to China and Indonesia. In Africa *H. erectus* evolved into *H.*
3 *ergaster* (for some, just an African version of *H. erectus*) who evolved later into *H. heidelbergensis*,
4 the presumed common ancestor of Neandertals and modern humans³. *H. heidelbergensis* and
5 immediate successors were adept tool users, likely fashioned aerodynamic javelins, brought down
6 large game, possibly used red ochre presumably for symbolic purposes, were regular fire users and
7 perhaps buried the dead. They dispersed throughout Western Europe and the bulk of skeletal
8 material comes from Atapuerca in Spain, dating to ~500 thousand years ago (kya).⁴ See Figure 1 for
9 a sketch of these developments.

10
11 After their split from this common ancestor, the Neandertal and modern human lineages continued
12 to diverge probably with minimal contact due to the very different and geographically distant areas
13 which they inhabited (western Eurasia versus Africa, respectively). By ~400 kya, individuals with
14 Neandertal features, marked by overall bodily robustness and specific cranial shape, were already
15 recognizable in Europe (Hublin 2009). The very robust body proportions were probably due to
16 adaptation to the glacial environments they inhabited, while the cranial typology was probably due
17 to genetic drift (Weaver 2009; Weaver *et al.* 2007). This was a period of dramatic climatic
18 fluctuations, and the Neandertal range expanded and contracted in response, extending as far north
19 as 55°N and as far east as South Siberia, and the Middle East in the south (Green *et al.* 2010;
20 Hublin 2009). This fluctuation of range may have been driven by a process of repeated local
21 extinction and recolonization rather than by wholesale population movements tracking the changing
22 habitats (Dennell *et al.* 2010; Hublin and Roebroeks 2009). Meanwhile, the lineage leading to
23 anatomically modern humans continued in East Africa, with early fossils of modern type from e.g.
24 Omo (~200 kya) and Herto (~160 kya) in Ethiopia. Modern (or near modern) humans then appear
25 in the fossil record of the Middle East just over 100 kya (Klein 2009:476), and by 70 kya had begun
26 their dispersal around the Old World. They overlapped with Neandertals first in the Middle East,
27 then elsewhere, entering glacial Western Europe late, somewhere before 40 kya. The current
28 evidence seems to point to a split of the two lineages by at least 400 kya, although there was
29 repeated contact between Neandertal and modern human populations from at least 100 kya.
30

31 **2.2. The emerging picture from ancient DNA**

32
33 Recent advances in genetics have allowed us to extract and analyze genetic material (ancient DNA,
34 or *aDNA*) from hominin fossils (see Disotell 2012 for a review). This rapidly developing field of
35 research has already revolutionized our understanding of human evolution and promises to continue
36 doing so. Therefore the following review must be taken as our interpretation, a current snapshot, of
37 the fast accumulating evidence.

38
39 As mentioned earlier, initial findings from recovered Neandertal DNA, using only mtDNA
40 (mitochondrial DNA), seemed to support the then current view that they did not contribute to the
41 modern human genetic diversity (Mellars 2005; Stringer and Andrews, 1988), either because of a
42 total lack of interbreeding or a relatively low initial contribution later lost (Hodgson and Disotell

3 We avoid binomial species names (i.e., *H. sapiens* and *H. neanderthalensis*) at this level on purpose, as they implicitly assume species-grade differences.

4 Here we gloss over the current nomenclatural controversy concerning *H. heidelbergensis* (e.g., Hublin 2009): the Atapuerca fossils are at least in a lineage close to this species. We are thus using *H. heidelbergensis* as the name of the most recent common ancestor of Neandertals, Denisovans and modern humans, attributing by default to this ancestor whatever can be shown to be common across the three lineages.

1 2008; Nordborg 1998, 2004; Relethford 2003, Serre *et al.* 2004, Weaver and Roseman 2005).
2 However, later advances in Next Generation sequencing allowed the publication of complete
3 Neandertal (Green *et al.* 2010; pre-publication release on 19 March 2013
4 <http://www.eva.mpg.de/neandertal/press-release.html>) and Denisovan (Reich *et al.* 2010; Meyer *et*
5 *al.* 2012) genomes, and, as foreseen by some (Relethford 2001, 2003; Nordborg 1998, 2004), these
6 revealed a much more complex story of interconnected genetic histories between three ancient
7 human lineages.

8
9 It was found that non-African living humans carry more shared derived alleles with Neandertals
10 than Africans do (Green *et al.* 2010), which was interpreted as suggesting that Neandertals and
11 modern humans interbred (admixture estimated at 1–4%, most probably about 2.5%) during the
12 latter's exodus from Africa, probably somewhere in the Middle East (other interpretations were also
13 offered; Hawks 2010; Hodgson *et al.* 2010). More recent work (Meyer *et al.* 2012; Wall *et al.* 2013)
14 found that this Neandertal contribution was not equally distributed across all non-African modern
15 humans, with about 20-40% less admixture in Europeans (estimated 6.4%) than in East Asians
16 (9.6%), pointing to more complex admixture scenarios with at least two separate episodes or a
17 protracted, low intensity interaction over tens of thousands of years. Alternative proposals
18 explaining these patterns as resulting from modern human population differentiation instead of
19 admixture (e.g., Eriksson & Manica 2012) have been rejected (Sankararaman *et al.* 2012; Wall *et al.*
20 2013). The most likely period in which these interbreeding events took place is between 47-65kya.
21 An equally interesting pattern has been found for Denisovans (a sister group to the Neandertals
22 identified only through their DNA), namely that they contributed (~4% besides the Neandertal
23 contribution) to the present-day Papuans, Melanesians and aboriginal Australians (Reich *et al.* 2010;
24 Meyer *et al.* 2012). Supporting these patterns of successful admixture is the finding that modern
25 humans, Neandertals and Denisovans share a karyotype with 23 pairs of chromosomes as opposed
26 to the other great apes which have 24 (Meyer *et al.* 2012).

27
28 Dating of the splits between these three ancient lineages (Denisovans, Neandertals and modern
29 humans) involves large uncertainties due to the incompleteness of the fossil record, uncertainties in
30 estimating mutation rates, and the difference between population (younger) and genetic (older)
31 divergences. Estimates have been on the order of 170-700 kya for the Denisovan-modern human
32 population split (Meyer *et al.* 2012) and 270-440 kya for the Neandertal-modern human split (Green
33 *et al.* 2010), but recent reassessments of mutation rates suggest, e.g. 420k to 780k for the latter
34 (Hawks 2012).

35
36 Thus, aDNA suggests that our evolutionary history is far from a simple and continuous progression
37 of a single lineage leading to us, but instead reflects a reticulated history, involving at least three
38 closely related branches that exchanged genes, probably repeatedly. One consequence is that we
39 should probably stop thinking about these three lineages as separate species (in the sense of Mayr's
40 1942 Biological Species Concept where interbreeding is definitional, but see Hey 2001 for many
41 alternative definitions). Indeed it seems likely that further ancient hominins will turn up, further
42 complicating this reticulated history. More interesting than the species question is how much
43 interbreeding actually took place and under which scenario, with some model-based estimates
44 suggesting that these might have been very rare events of less than 2% (and as low as 0.5% in some
45 scenarios) successful matings (Currat & Excoffier 2011) or 1 mating in 12-77 generations (Neves &
46 Serva 2012). However, more work is needed given various complicating factors such as differences
47 in population size and later demographic events. It is important to appreciate that different
48 Neandertal genes are found in different modern human individuals, which "suggests that the
49 number of contacts was not very small – more like the low thousands or high hundreds than

1 dozens” (Hawks 2013). Whatever the rates of interbreeding, the genes acquired by modern humans
2 may have been crucial. For it is possible that some Neandertal and Denisovan genes conferred
3 strong selective advantages in the out-of-Africa environment, especially in the immune system, and
4 have very high frequencies in modern populations despite low levels of interbreeding (Hawks and
5 Cochran 2006). Proposals include immune system genes such as in the HLA system (Abi-Rached et
6 al., 2011), the STAT2 gene (Mendez et al 2012) and the OAS gene cluster (Mendez et al 2013b).

7
8 More important, however, is what the direct comparisons between the Neandertal, Denisovan and
9 modern genomes can tell us about their similarities and differences. As expected given their recent
10 common ancestry and their successful admixture, these three genomes are extremely similar,
11 sharing the vast majority of innovations since the split from chimps (Green et al 2010; Meyer et al
12 2012), such as ~91% of the “human accelerated regions” (HARs) – parts of the genome that
13 changed since that split, but are otherwise very stable throughout vertebrates. Potentially relevant
14 for language and speech, they share for example the same “human specific” two amino-acid
15 substitutions in *FOXP2* (Krause *et al.* 2007), the best-known gene hitherto linked to language,
16 lending support to our hypothesis that Neandertals were language users (Trinkaus 2007).

17
18 Nevertheless, there are subtle differences between the genomes of the lineages: while the *FOXP2*
19 exons (the protein-coding sequences) are identical, recently Maricic et al. (2012) have reported that
20 a regulatory element within intron 8 of *FOXP2* binding the *POUF3* transcription factor differs
21 between Neandertals and modern humans and might have been the target of recent positive
22 selection since their split (Ptak et al 2009). However, it is currently unclear what effects this change
23 has and, importantly, the ancestral (“Neandertal”) allele is still present at ~10% frequency in
24 present-day Africans (Maricic et al. 2012), showing that this variant is well within the modern
25 human variation⁵. Besides genes affecting the skin (*TRPM1*, *HPS5*), the eye (*RP1L1*, *GGCX*),
26 metabolism (*THADA*), the skeleton (*RUNX2*) and dentition (*EVC2*), some genes affecting the brain
27 and nervous system are also different between us, on the one hand, and the Neandertals and
28 Denisovans on the other (Green et al 2010; Meyer et al 2012). A recent review (Somel et al 2013)
29 lists several such genes including the intron 8 of *FOXP2* and a protein change in *CNTNAP2*⁶
30 (another gene implicated in speech and language; Fisher and Scharff 2009, Vernes et al 2008),
31 *MCPHI* and *ASPM* (brain development; Cox et al 2006), the dopamine receptor gene *DRD5*, and
32 *MEF2A*, a gene perhaps involved in prolonged developmental plasticity of the brain.

33
34 Taken together, these suggest that Neandertals, Denisovans and modern humans were very similar,
35 although of course not identical, hominins. More research will help clarify what these small
36 differences entail, and to what extent they are within the range of modern human variation, but we
37 would propose that they are likely to be quantitative in nature. It is important, however, to keep in
38 mind that the human genome is very complex and that regulatory changes can have hard-to-predict
39 effects, making any inferences from the identity (or not) of gene sequences to speech and language
40 necessarily tentative. Nevertheless, the genetic story so far suggests that Neandertals and
41 Denisovans had the basic genetic underpinnings for recognizably modern language and speech, but

⁵ It is important to highlight how much we do not yet know about human genetic variation: recently Mendez et al (2013a) reported the totally unexpected fortuitous discovery of a Y chromosome in a living African American so divergent that its most recent common ancestor with the other Y chromosomes must be pushed back to 237-581 kya, older than the fossil evidence for modern humans.

⁶ However, it is unclear what exactly this aminoacid change in the Laminin G-like domain of the CASPR protein (the product of *CNTNAP2*) does. This results in the replacement of the primitive (non-human primates, Neandertals and Denisovans) isoleucine by the derived (modern human) valine, but these aminoacids have similar properties, and valine is also present in for example mice and rats (Cuadrado, et al, *in press*).

1 it is possible that modern humans may outstrip them in some parameters (perhaps range of speech
2 sounds or rapidity of speech, complexity of syntax, size of vocabularies, or the like).
3
4

5 **2.3. The skeletal morphology**

6
7 Neandertals are considered to form a relatively coherent group of fossils. Morphologically, they are
8 characterized by cranial differences from modern humans and by post-cranial robustness (Klein
9 2009). The cranial differences involve long and low braincases with volume comparable to (even
10 exceeding) that of modern humans, and the face was prognathous with projecting dentition, and
11 chinless. Many minor details, such as dentition and angle of the semicircular canals, are distinctive.
12 The rest of the differences amount to very robust upper limbs, revealing remarkable muscular
13 strength, and general stockiness reflecting adaptation to the cold climates they inhabited. The
14 robustness may be a reflection of recurrent bio-mechanical loading (and thus cultural differences in
15 life style) as much as of genetic differences (Klein 2009:461), with the cranial morphology as
16 mentioned most probably a result of genetic drift (Weaver 2009; Weaver *et al.* 2007).
17

18 These differences between modern humans and Neandertals increased over time, and the “classic”
19 Neandertal phenotype is found between 190-30 kya. Nevertheless, there may be some intermediate
20 fossils, possibly reflecting the interbreeding that we now know to have occurred through the DNA
21 evidence reviewed above. Probably the best-known case is represented by the child discovered at
22 the Abrigo do Lagar Velho, Portugal (Duarte *et al.* 1999), which has been interpreted as a
23 Neandertal-modern human hybrid dating from about 24kya (Duarte *et al.* 1999; Trinkaus and Zilhão
24 2003), an interpretation apparently supported by the recent analysis of its pattern of dental
25 development (Bayle *et al.* 2010).⁷ Given the burial context, it has been argued that the child had
26 been accepted as a full member of the community speculating that this type of admixture was
27 viewed as tolerable at least, and was frequent enough to gain social acceptance (Zilhão and
28 Trinkaus 2003). However, this interpretation is hotly contested (e.g., Tattersall & Schwartz, 1999)
29 and must be taken as speculative. Other remains which have been suggested to show signs of dual
30 ancestry (Trinkaus 2007) include the European early modern humans from Peștera cu Oase
31 (Rougier *et al.* 2007; Trinkaus *et al.* 2003), Peștera Muierii (Soficaru *et al.* 2006), Mladeč
32 (Teschler-Nicola 2006), and Riparo Mezzena, Italy (Condemi *et al.* 2013), but these interpretations
33 are far from being generally accepted.
34

35 Before the recent DNA evidence became available, there was no consensus as to whether these
36 gross physical differences were enough to presume that modern humans and Neandertals
37 constituted different species (see Dediu 2007). This reflects the many distinct notions of species in
38 biology (Hey 2001, lists 24 definitions), and in part it stems from different animal models used.
39 Interbreeding might be taken as evidence that modern humans, Neandertals and Denisovans all
40 belonged to one biological species, but introgression (back-crossing of fertile hybrids with a parent
41 species) does occur across species boundaries (Mallet 2005).
42

⁷ The most recent certain date for Neandertals in Europe comes from Gibraltar, with a radiocarbon date of 28kya, but they may have hung on longer (Finlayson *et al.* 2006). Using more refined dating techniques, all these dates may be upward revised (Wood *et al.* 2013), but they continue to imply some considerable overlap of Neandertals and modern humans in the west, with more extended overlap in eastern Eurasia.

1 **2.4. Neandertal infant maturation**

2
3 One important (but contentious) area concerns the developmental schedule for maturation of
4 Neandertal infants. Modern human infants develop slowly after birth, resulting in a dependency
5 during the first years of life crucial for the learning of language and other aspects of culture. The
6 developmental trajectory in turn depends on the size of the birth canal: if small, infants will be more
7 dependent and birthing will be difficult, suggesting “obligate midwifery and all of the attendant
8 social implications” (Franciscus 2009:9126).

9
10 Weaver and Hublin (2009) report the reconstruction of a Neandertal birth canal and conclude that
11 there are some differences in the orientation of the neonate during birth, but that the pelvic area of
12 humans and Neandertals was very similar and that “a human-sized neonate would have been able to
13 pass through Tabun's birth canal” (p.8154). Likewise, the neonate brain size was similar to that of
14 modern humans (de León *et al.* 2008), but the developmental trajectory seems to have been
15 relatively different (Gunz *et al.*, 2010). Recent evidence (Lalueza-Fox *et al.* 2010) from a
16 Neandertal family assemblage was interpreted as indicating an interval of about 3 years between
17 consecutive births, similar to that reported for modern hunter-gatherer groups. This suggests that the
18 Neandertal life history was as slow, or even slightly slower, than that of modern humans, with the
19 origin of this pattern predating the last common ancestor of these lineages. This inference seems
20 supported, among others, by the analysis (de Castro *et al.* 1999, 2010) of the dental eruption pattern
21 shown by a mandible attributed to *Homo antecessor* (0.8-0.96 mya) suggesting that a prolonged
22 childhood similar to that of modern humans is a relatively early characteristic of the genus *Homo*.

23
24 We may expect further insight into these issues as we come to understand what the differences
25 between modern and Neandertal DNA imply functionally (section 2.2): for example *MEF2A* has
26 recently been suggested to be involved in extending brain plasticity in our lineage and underwent a
27 regulatory change in the last 0.5m years (Somel et al 2013). Therefore, it is possible that this could
28 imply a somewhat different developmental trajectory and gene expression in the prefrontal cortex
29 with a more limited period for the acquisition of a complex learned communication system in
30 Neandertals.

31
32 Thus, the evidence so far seems to point to a similar but not identical pattern of birth and slow
33 development in Neandertals and modern humans, capable of supporting the cultural transmission
34 required for complex language and culture. Moreover, it seems highly probable that hybrids
35 resulting from mixed mating would have been able to be born by mothers of any lineage and would
36 have been capable of normal development.

38 **3. Neandertal speech, language and culture**

40 **3.1. Speech and hearing**

41
42 Fossilized parts of the vocal and auditory anatomy provide important information about ancient
43 capacities for speech production and perception. In principle, combined with appropriate models,
44 they could allow relatively robust inferences concerning the capabilities of past humans. But, in
45 practice, it turns out that there is enough latitude for fierce debates concerning the appropriateness
46 of the models used and their capacity to distinguish competing hypotheses (Fitch 2009a).

1
2 In species with elaborate conspecific communication systems, there tends to be a precise match
3 between the broadcast bandwidth and the tuning of perceptual acuity (see e.g. Kojima 1990; Lafon
4 1968). The possession of articulate speech therefore implies that both production and perception
5 are attuned to each other, so that parameters carrying the bulk of the speech information are
6 optimized in both production and reception.
7

8 Human audiograms differ from those of other living primates by showing higher sensitivity in the
9 1-6 kHz range and especially between 2-4 kHz, just where chimpanzees show a relative loss in
10 sensitivity (Martínez *et al.* 2004, 2008). Using 3D CT-scans of five fossil individuals from the Sima
11 de los Huesos site in Spain, Martínez and colleagues (2004) reconstructed the anatomy of their
12 external and middle ear, to which they further applied an electrical circuits model of the sound
13 power transmission through these structures. The results suggest that these fossil hominids had a
14 modern human-like pattern of sound perception, which clearly differs from the chimpanzee pattern
15 in the region around 4 kHz (Martínez *et al.* 2004, 2008), strongly supporting the inference that their
16 hearing apparatus could support modern speech perception (for a more skeptical position, see Fitch,
17 2010:325). By the principle of the matching of broadcast and perception bandwidths, we can
18 presume that speech was produced in the current auditory range. The interesting twist is that these
19 fossils are attributed to *Homo heidelbergensis* and date from approximately 500 kya, that is around
20 or shortly after the time that the lineages of Neandertals and modern humans may have initially
21 separated. Even if these fossils belong to the evolutionary lineage leading not to modern humans
22 but to Neandertals, the date nevertheless suggests that modern audition almost certainly predates the
23 common origin of these two lineages.
24

25 Quam and Rak (2008) have recently described and analyzed a new set of Neandertal and modern
26 human ear ossicles from Qafzeh and Amud which date 50-100 kya. They conclude that the range of
27 morphological variation in the Neandertal ear bones is included within the modern human range
28 and that what may differ are the relative frequencies of these variants in the two populations.
29 Therefore, it can be safely concluded that Neandertal ear ossicles are essentially modern, further
30 supporting the idea that their audition was very similar, if not identical, with that of modern
31 humans.
32

33 On the production side, there has been considerable controversy focused on the descent of the
34 larynx and the role of the hyoid bone. Nevertheless, we think it is clear that the number and
35 diversity of clues, taken together, clearly point in the direction of a modern capacity for speech in
36 the common ancestor of Neandertals and modern humans. Neandertal hyoids are essentially modern
37 (from Kebara, Israel; Arensburg *et al.* 1989, 1990; from El Sidrón, Spain; Rodríguez *et al.* 2003,
38 and from Sima de los Huesos, Spain – from *Homo heidelbergensis*; Martínez *et al.* 2008). The
39 modernity of the Neandertal hyoid contrasts markedly to the archaic characteristics of the *Homo*
40 *erectus* specimen from Castel di Guido, Italy (Capasso *et al.* 2008) and of the *Australopithecus*
41 *afarensis* specimen from Dikika, Ethiopia (Alemseged *et al.* 2006). The morphology of the hyoid
42 bone is intimately connected to the issue of air sacs, present in many primate species (de Boer
43 2009): these are cavities filled with air and connected to the vocal tract (Hewitt *et al.* 2002). Their
44 acoustic function is not entirely clear, but recent work (de Boer 2009) seems to suggest that their
45 presence has deleterious effects on speech by reducing the range of distinctive speech sounds which
46 can be produced. Thus, given the current fossil evidence, air sacs had probably disappeared between
47 *H. erectus* and the last common ancestor of modern humans and Neandertals.
48

49 While admitting that the Neandertal hyoid bone was essentially modern in morphology, Fitch

1 (2009a) argues, following Laitman *et al.* (1990), that this is not enough to prove a modern position
2 within the vocal tract, nor a modern capacity for speech. The position of the hyoid bone within the
3 vocal tract has received a lot of attention since the proposal by Lieberman and Crelin (1971) that it
4 can be inferred from features of the cranium (the styloid processes or basicranial angle) and that this
5 position can tell us something about the vocal capabilities of fossil hominids. However, as
6 extensively shown by subsequent work (DuBrul 1977; Falk 1975; Fitch 2009a; Houghton 1993; Le
7 May 1975), the position of the hyoid cannot be safely inferred from the skeletal features suggested
8 and the high position of the Neandertal hyoid proposed by Lieberman and Crelin (1971) cannot be
9 justified, with a lower position being, in fact, much more probable. Moreover, as demonstrated by
10 Fitch (2000, 2009a), many mammals can dynamically lower their larynx during vocalizations,
11 implying that the “rest” position is not necessarily a good indicator of the dynamic vocal
12 capabilities. A further complication is added by the fact that Boë *et al.* (2002) have claimed, using
13 an articulatory model, that the vowel space of Neandertals with a high hyoid was comparable to that
14 of modern humans; but these results have been recently challenged (de Boer and Fitch 2010) on
15 grounds of circularity, as they were using a model developed on modern human data. Nevertheless,
16 we concur with Fitch (2009a)'s conclusion that “the significance of the descent of the larynx [...]”
17 has been overestimated” (p.133) (see also Nishimura *et al.* 2006).

18
19 Two other proposed fossil clues allowing inferences related to the evolution of speech concern
20 traces of the capacity to control the tongue (the hypoglossal canal) and the respiratory muscles (the
21 thoracic vertebral canal), respectively (Fitch 2009a). The first clue seems to be unable to offer much
22 information, as the size ranges in modern humans and other apes, including chimps, show
23 substantial overlap (DeGusta *et al.* 1999; Jungers *et al.* 2003). However, the second is crucial, for
24 voluntary control of breathing is a prerequisite for any complex speech production (MacLarnon and
25 Hewitt 1999), and this requires cortical control taking over from the autonomous respiratory control
26 in the brain stem. This is achieved by extra enervation of the intercostal muscles and diaphragm,
27 visible in fossils as an enlarged vertebral canal. The crucial evidence is that the Nariokotome boy (a
28 well-preserved *H. erectus*) has no such enlarged canal, but both modern humans and Neandertals
29 do, implying that the common ancestor also did. Every stage of speech production depends on this
30 cortical control, which allows the sharp in-breath, the slow release and volume modulation required.
31 This crucial ingredient, for which there is no likely other motivation, is thus present before 0.5 mya.

32
33 The voluntary control system is particularly relevant for the issue of vocal imitation and learning
34 (Fitch 2010:350), which is normally described as rare in the primate order (but see e.g. Wich *et al.*
35 2012). Direct evidence of vocal imitation in fossil hominins is of course missing, but precise tool
36 replication provides ample evidence for the necessary cognitive capacity in another modality.

37
38 In sum, the evidence points to modern speech capacities in the common ancestor of Neandertals and
39 modern humans. The auditory specializations for speech on the modern bandwidth are present, the
40 morphology of the larynx looks modern, and air sacs have been replaced by a finely controlled
41 pulmonic airstream mechanism for vocalization. In addition, the gene that is known to be involved
42 in the fine motor control necessary for speech, *FOXP2*, has its modern form (although possibly not
43 all of its modern regulatory environment). Interestingly, all these changes occurred in the transition
44 from *Homo erectus* to *Homo heidelbergensis*, the common ancestor to both Neandertals and modern
45 humans. We suggest therefore that this common ancestor was an articulate mammal.

46
47 Now, there is an old strand of speculation going back to Darwin (1871) that imagines a scenario in
48 which speech evolved under sexual selection for “producing true musical cadences, that is in
49 singing” (see discussion in Fitch 2009b; Mithen 2005). Preadaptation of speech for something other

1 than language cannot be ruled out, but the perceptual bandwidth mirroring modern speech looks
2 undermotivated for singing (which in modern humans is mostly concentrated at the higher end of
3 the bandwidth used in speech). In addition, it is notable that the relevant animal models for singing
4 as a possible precursor to language are not found among the social species; social mammals have
5 acquired vocal learning through other routes, namely for broader social communication.
6 Neurologists have long noted double dissociations between amusia and aphasia, i.e. loss of musical
7 ability and loss of speech, and cognitive scientists have pointed to many ways in which the
8 processing systems seem to be distinct (Peretz 2006). Even the most enthusiastic proponents of
9 processing overlap between language and music admit that music diverges in fundamental ways,
10 such as its organization of pitch and rhythm, the absence of a categorical basis, and its lack of
11 propositional meaning (Patel 2008). If there was any singing precursor to language it must lie right
12 back at the beginning of the human lineage, millions of years ago. There are moreover many other
13 reasons to suspect language was present to utilize the speech channel, which we now turn to.
14
15

16 **3.2. Culture and language**

17
18 The Neandertals had a complex stone tool technology (the Mousterian) that required considerable
19 skill and training, with many variants and elaborations (see Klein 2009:485ff). They sometimes
20 mined the raw materials at up to 2 metres depth (Verri et al 2004). Their stone tools show wear
21 indicating usage on wood, suggesting the existence of a wooden material culture with poor
22 preservation, such as the carefully shaped javelins made ~400 kya from Germany (Thieme 1997).
23 Tools were hafted with pitch extracted by fire (Roebroeks & Villa 2011). Complex tool making of
24 the Mousterian kind involves hierarchical planning with recursive sub-stages (Stout 2011) which
25 activates Broca's area just as in analogous linguistic tasks (Stout & Chaminade 2012). The chain of
26 fifty or so actions and the motor control required to master it are not dissimilar to the complex
27 cognition and motor control involved in language (and similarly takes months of learning to
28 replicate by modern students).⁸ The Neandertals managed to live in hostile sub-Arctic conditions
29 (Stewart 2005). They controlled fire, and in addition to game, cooked and ate starchy foods of
30 various kinds (Roebroeks & Villa 2011, Henry et al 2010). They almost certainly had sewn skin
31 clothing and some kind of footwear (Sørensen 2009). They hunted a range of large animals,
32 probably by collective driving, and could bring down substantial game like buffalo and mammoth
33 (Conard and Niven 2001; Villa and Lenoir 2009).
34

35 Neandertals buried their dead (Pettitt 2002), with some but contested evidence for grave offerings
36 and indications of cannibalism (Lalueza-Fox *et al.* 2010). Lumps of pigment – presumably used in
37 body decoration, and recently found applied to perforated shells (Zilhao et al 2010) – are also found
38 in Neandertal sites. They also looked after the infirm and the sick, as shown by healed or permanent
39 injuries (e.g., Spikins *et al.* 2010), and apparently used medicinal herbs (Hardy et al 2012). They
40 may have made huts, bone tools, and beads, but the evidence is more scattered (Klein 2009), and
41 seemed to live in small family groups and practice patrilocality (Lalueza-Fox *et al.* 2010).
42

43 The inference of language capacity from the archaeological record is a controversial endeavor
44 (d'Errico and Vanhaeren 2009) and the dangers of such inferences are well illustrated by the myth of

⁸ A reviewer queries whether genuine hierarchy exists in action sequences, suggesting that these can be reduced to a TOTE structure (Miller et al 1960). But as soon as one subroutine calls another, as in the case of complex tool manufacture, genuine hierarchy is involved. See also Levinson (2013).

1 the “modern human revolution”. This is the proposal that the cultural efflorescence seen in Upper
2 Paleolithic Europe from ~40 kya was due to a fundamental cognitive shift resulting from a sudden
3 mutation giving rise to a new species possessing the so-called “modern package” (e.g., Bickerton
4 2002; Donald 1999; Dunbar 1996; Gabora 2003; Mithen 1996). Some of the differences between
5 Neandertals and modern humans that are often invoked concern the lack of art and personal
6 ornaments, the absence of large-scale exchange networks or projectile weapons, the meager
7 investment in campsites, the relatively narrow range of prey and in particular the apparent neglect
8 of fishing (Henshilwood and Marean 2003; Klein 2009; Mellars 2005; McBrearty and Brooks 2000;
9 Roebroeks and Verpoorte 2009; Stringer 2002).

10
11 However, many of these “hallmarks” of modern human behavior found in the European Upper
12 Paleolithic turn out to be quite exceptional features of pre-Neolithic human cultures. The
13 ethnographic records of first contact with most hunter-gatherer groups lack all these material
14 expressions of symbolic exuberance: most symbolic activity, like language, simply does not
15 fossilize. Nothing like the European Upper Paleolithic explosion of symbolism is found among the
16 early colonizers of the Americas – but they were modern humans just 12,000 years ago. It is worth
17 pointing out too that the notion of symbolism invoked in these discussions has little to do with
18 language: the peculiarity of linguistic symbols is that they denote by abstract convention, while a
19 cave painting of a horse denotes by iconic similarity, a principle that plays a very minor role in
20 language. In addition, some of the apparent Neandertal failings, like lack of use of marine
21 resources, now seem artifacts of the sites investigated earlier (see Alperson-Afil et al 2009).

22
23 The myth of a “modern human revolution” is now rejected by archaeologists, although it lingers on
24 in linguistic circles, as illustrated, for example, by Chomsky (2010). The myth dissolves as soon as
25 one considers the archaeological record of the whole Old World, and especially of Africa, where a
26 gradual, piece-meal process of cultural accretion took hundreds of thousands of years (McBrearty
27 and Brooks 2000). The supposed lack of signs of symbolic activity has been exploded with the
28 recent discovery of personal ornaments and pigments at Neandertal sites (d’Errico and Vanhaeren
29 2009; d’Errico and Soressi 2002; Watts 2009), intentional burials in fetal position, possibly with
30 grave goods (Grün and Stringer 2000, Klein 2009) and other “hallmarks” of modern human
31 behavior (Riel-Salvatore 2010; Shipman 2008). The case of the decorated pendants in the Arcy
32 Chattelperronian is hotly debated (see below; Higham 2010, Caron et al 2010). But perforated
33 shells with ochre colouring extracted from sources at some distance have recently been found in
34 Spain, dating to about 50kya, long before contact with modern humans in that region (Zilhao et al
35 2010). In addition, on the other side of the coin, why did anatomically modern humans fail to invent
36 the cultural assemblages they later produced in Europe earlier in the 150,000+ years leading up to
37 their colonization of those parts? They were cohabiting with the Neandertals in the Levant for
38 perhaps some 50,000 years, using the identical basic material culture (Klein 2009). Part of the
39 answer may be that the abilities were present but dormant in both lineages, awaiting a *cultural*
40 *revolution* that itself spurred a demographic revolution in, and an exodus from, South and East
41 Africa (Mellars 2006).

42
43 The range of classic Neandertal brain sizes fully overlaps the range of modern humans (Klein
44 2009:308) and correcting for body mass highlights this similarity (Klein 2009:728). It is possible
45 however that the structure of their brains might have not been identical to that of modern humans:
46 the “occipital bun” suggests a possible development of visual areas which could point to a relatively
47 different cognitive style (Pearce et al 2013). If we follow Dunbar (1993), using the predictions
48 based on neocortex sizes, even accepting the recently proposed adjustment for body size and a
49 larger visual system (Pearce et al 2013), Neandertals would be expected to have had large group

1 sizes (~115), relatively similar to modern human hunter-gatherers (~144), requiring complex social
2 systems.
3

4 Especially interesting is the late Neandertal period of contact with modern humans when there are
5 numerous signs of cultural borrowing. The Châtelperronian (e.g., Floss, 2003) is associated with
6 Neandertals and a clear blend of the Neandertal Mousterian technology and the modern human
7 Aurignacian technology. The stone tool assemblages include both types, there are symbolic
8 elements like bone bead and pendants, complex foundations for ancient huts, etc., strongly
9 suggesting cultural diffusion of modern human technology to Neandertals (Klein 2009:655).
10 Recently, some doubt has been cast on whether the personal ornaments found at Arcy-sur-Cure in
11 Châtelperronian layers were actually made by Neandertals – some argue they must be intrusions
12 from later modern human strata (Higham et al 2010, Mellars 2010), but this now seems unlikely
13 (Caron et al. 2011, Hublin et al. 2012). A similar pattern would be found in the ethnographic record
14 of early colonial contact with indigenous peoples, namely a rapid adoption of new technology.
15 Cognitive capacity is obviously best measured by the ability to adopt diffused technology rather
16 than by the ability to invent it, which owes much to cultural advance.
17

18 Neandertal culture, basically identical to modern human cultures before the Upper Paleolithic
19 innovations, seems also to fall within the spectrum of modern human cultural variation in the
20 ethnographic record. Various modern hunter-gatherers have produced archaeological records very
21 similar or even considerably simpler than the Neandertal ones (Roebroeks and Verpoorte 2009),
22 some well-known examples being the North American early Archaic (Speth 2004) and the
23 Tasmanians (Richerson *et al.* 2009), who lacked bone tools, clothing, spear throwers, fishing gear,
24 hafted tools and probably the ability to make fire (Henrich 2004). Recollect also the Yaghans of
25 Tierra del Fuego whose complete nakedness in frigid conditions and absence of all but the simplest
26 material culture so amazed Darwin: "without exception the most curious and interesting spectacle I
27 ever beheld: I could not have believed how wide was the difference between savage and civilised
28 man: it is greater than between a wild and domesticated animal." (Darwin 1845:Ch. 10, p. 216).
29

30 Like these groups of modern humans with rather simple technology, the relative cultural simplicity
31 of Neandertals compared to European modern humans can probably be best understood in its
32 *demographic* context. Neandertal populations of Europe had something like one tenth the
33 population of the modern humans who immediately succeeded them (Mellars & French 2011). In
34 general, Neandertals had very low population densities, which coupled with the repeated local
35 extinction and recolonization (Dennell *et al.* 2010; Hublin and Roebroeks 2009, Dalén et al. 2012),
36 would have inhibited the growth of complex technology. There are intimate relationships between
37 demography and cultural complexity, which can be partly understood in terms of cultural niche
38 construction, the process by which organisms can significantly alter the selective environment they
39 inhabit (Habgood and Franklin 2008; Kline and Boyd 2010; Powell *et al.* 2009; Richerson *et al.*
40 2009). The kind of cultural and technological elaboration characteristic of the post-Neolithic is
41 intrinsically connected to intensive population pressure, and the ecological reworking associated
42 with it. One possible reason for the cultural limitations of small populations has to do with the
43 transmission fidelity of culture, with only larger populations having the variance and division of
44 labor to maintain the quality of skills (Henrich 2004; see though Read 2006).
45

46 However, language seems to behave in a different manner, due to its design properties which
47 require 'parity' (similarity of systems) between communicators: here, large populations erode
48 complexity (because of the need to communicate across groups), and small ones allow (but do not
49 require) it. Consequently, highly complex languages (with elaborate morphology and irregularity)

1 tend to be spoken by small groups (Lupyan and Dale 2010). From this, we might conjecture that
2 Neandertal languages may have had more complex categories than the languages spoken by the
3 often larger modern human groups that followed, and in particular by contemporary large-scale
4 societies. We can speculate that they perhaps had the features typical of languages spoken in small
5 traditional societies today: sizable phoneme inventories, complex morphosyntax, high degrees of
6 irregularity, and vocabularies in the tens of thousands. We can also be fairly sure, due to the
7 relatively isolated nature of the groups, that there were many distinct languages. We could even
8 hazard the prediction on the basis of the genes they carried, that the chances are they spoke tone
9 languages (Dediu and Ladd 2007), as will be made clear in the discussion below. All this is
10 speculation, but perhaps as our knowledge of the sociolinguistics of small-scale societies and of
11 functional genetics improves, we may be able to put these guesses on a firmer basis.

12
13 It seems that speculations on human prehistory often deny cultural elaboration itself the causal role
14 it so clearly deserves. Greater cultural elaboration must, the arguments seem to imply, depend on
15 something else: greater intelligence, a speciation event, or some biological basis for an independent
16 demographic spurt. But human culture is a spiral which under the right conditions will simply
17 ratchet up. The right conditions are time left over from subsistence activities, strong norms of
18 parental investment in the young, relative health, sufficient peer competition, ecological wealth for
19 conspicuous consumption, etc. These enabling conditions have to be met, and then incremental
20 cultural transmission will do the rest. There is no other way to explain the cultural diversity in the
21 modern ethnographic world. The early modern humans that invaded Europe and eventually replaced
22 the Neandertals had the advanced technology, just like Captain James Cook had when he arrived in
23 Australia in 1770 – Cook’s advantage wasn’t his smarts so much as thousands of years of
24 accumulated technological prowess.

25
26 Thus, we believe there is no argument to be made from Neandertal culture to the absence of
27 language. The paucity of preserved symbolic material is also observed in early modern humans,
28 and many modern ethnographic settings. On the contrary, nothing like Neandertal culture, with its
29 complex tool assemblages and behavioral adaptation to sub-Arctic conditions, would have been
30 possible without recognizably modern language.

31
32 Finally, we should turn to the issue of Neandertal extinction, often presumed to be a consequence of
33 cultural and technological failure – modern humans wiped them out, as we continue to do to so
34 many other species, and indeed to small ethnic groups of our own species. At the present, there is
35 no clarity on this issue. On the one hand, there were long periods of coexistence with modern
36 humans, especially outside Western Europe (and up to 10,000 years within it, as mentioned earlier),
37 and much evidence of cultural borrowing as reviewed. On the other hand, some redating of fossils
38 suggests that Neandertals may have retreated from areas of Europe before modern humans ever got
39 there, under the severe conditions of the last glaciation (OIS3; see Stewart 2005; Wood et al 2013).
40 Some scholars incline to the view that Neandertal populations were absorbed rather than
41 extinguished, hence the intermediate traits sometimes found in late Neandertals (Condemi et al
42 2013). Their demography was always fragile. It is worth remembering that many modern human
43 pioneers in difficult environments (like the Norse of Greenland) also simply failed to make it
44 through. Perhaps the disappearance of Neandertals was due to some mix of climate change,
45 absorption, competition and genocide.

46

47 **4. Consequences for the study of language and linguistics**

48 As stated at the outset, we understand language as the full suite of abilities to map sound to

1 meaning, including the infrastructure that supports it (vocal anatomy, neurocognition, ethology of
2 communication, theory of mind, etc.). The assemblage of these prerequisites took place in deep
3 time, we have argued, so that speech and language are ancient, being present in a modern-like form
4 over half a million years ago in the common ancestor of Neandertals and modern humans, the result
5 of evolution in the prior one million years or so as *H. heidelbergensis* evolved from *H. erectus*. If
6 accepted, that multiplies the time depth of modern language capacities between five and tenfold
7 over the numbers (typically 50,000 or 100,000 years) often mentioned in the literature in the
8 language sciences.

9
10 After *H. heidelbergensis*, biological and cultural evolution continued in each human lineage (and
11 still goes on in present-day humans; Dediu & Ladd, 2007), one inside and one outside Africa,
12 resulting in the accumulation of cultural, and no doubt some minor biological, differences in speech
13 and language. Thus, when the two groups met again, during the modern human expansions out of
14 Africa from 100kya, we would argue that their speech and language capacities would have been
15 comparable and compatible. We list below some of the direct consequences of this perspective.

16
17 *First*, a simplistic saltationist story, involving a point mutation, as proposed by, for example,
18 Chomsky (2010), can no longer be supported. Instead we have to think in terms of an evolutionary
19 trajectory where language and cognitive abilities accumulate and change, a process still ongoing to
20 this day. Pinker and Bloom (1990) made the case twenty years ago for viewing language as a
21 complex adaptive system that has evolved under natural selection for the purposes of
22 communication, but their arguments seemed weak against the then proposed time-scale for
23 language evolution in the last 50,000 years or so: how could such a complex, intricate system have
24 evolved in a mere couple of thousand generations? The recognition of the antiquity of language
25 removes this impediment to an evolutionary account of the emergence of modern language.⁹

26
27 Incidentally the view that language evolved over deep time does not entail (phyletic) gradualism,
28 the idea that evolution moves at a fixed pace by successive tiny adaptations – not even Darwin
29 (though mesmerized by Lyell’s geological perspective) ever held that view. As far as language is
30 concerned, the assemblage of the prerequisites for speech and language in the transition from *H.*
31 *erectus* to *H. heidelbergensis* may well have been punctuated at times by relatively large changes in
32 language-related features. Our reading of the current ancient DNA evidence is that the later split
33 into the three (currently known) interbreeding lineages does not seem associated with punctuated
34 and rapid development of many language-related genes in our own lineage in the last hundred
35 millennia or so – but we can rely on rapid progress in this field to clarify the issues here. Thus, to
36 hazard a prediction, we expect that most of the genetic differences between modern humans,
37 Neandertals and Denisovans (and the yet-to-be-discovered lineages) are in terms of non-fixed
38 shared alleles and the few that are fixed result in quantitative and relatively small differences in
39 speech and language.

40
41 On the view advanced here, speech and language were largely co-evolving capacities and the study
42 of speech production and comprehension ought to come back to center stage, where it has been
43 displaced by an emphasis on syntax. For example, we need to better understand the genetic
44 foundation for the cortical control of breathing, the tongue, the velum and the vocal folds, for this
45 may give us better clues to the sequence of evolutionary adaptations involved. Absent from other

⁹ A reviewer remarked that “no one has ever disagreed” that language evolved under natural selection, but in fact Chomsky and colleagues have systematically done so. See for example Chomsky (1972:97; 1988:170, 183) and Berwick (1998: 322).

1 primates, for example, is the lateral cortical system, providing direct connections between cortex
2 and larynx (Fitch 2010:350). The idea that human language initially went through a sign-language
3 or gestural language phase has become popular again in part through the discovery of mirror-
4 neurons, offering an apparently automatic translation from manual action to action-understanding
5 (Arbib 2005). In addition, Call and Tomasello (2007) have cogently argued that ape gesture is
6 connected to intentional communication while ape vocalizations are more reflex signals (as
7 reflected in the lack of cortico-laryngeal connections). Nevertheless, any supposed phase of purely
8 gestural communication must date back at least as far as early *H. erectus*, and thus a million or
9 more years ago. There is no evidence whatsoever of adaptation of the hand to communicative
10 functions, while there is ample evidence of systematic adaptation of the vocal apparatus to speech,
11 and we have shown that this was more or less in place by half a million years ago. Modern human
12 communication is intrinsically multimodal, using gesture and speech, or at least hand and mouth
13 and face, as evident in any current human interaction – this appears to be a single system. The
14 recurrent natural emergence of sign languages attests to the unified nature of a hand+mouth system,
15 since sign languages merely shift the burden from mouth to hand but use both.

16
17 *Second*, the deep time frame supports the idea that the foundations for language were incrementally
18 acquired. Hurford (2003), amongst many others, has tried to spell out these pre-adaptations. Early
19 candidates would be the *cooperative instincts* (Tomasello 2008) and the interactional ethology
20 typical of all modern humans (Levinson's 2006 'interaction engine'), making possible the cultural
21 transmission of tool-making visible in the archaeological record. Universals in language usage
22 reflecting this interactional infrastructure for communication seem considerably more invariant than
23 language structure (Stivers *et al.* 2009) and evidenced in early infancy, suggesting ancient
24 phylogeny. Crucial here is the intention recognition that underlies human communication but is
25 separately instantiated in neurocognition (Noordzij *et al.* 2010). Developing a finer-graded set of
26 distinctions in these underlying capacities will make it easier to search for precursor abilities (Haun
27 *et al.* 2006). The increasingly complex speech system must have come later, with the more complex
28 aspects of language – phonology, syntax, and lexicon – being the last to evolve. Understanding the
29 relative roles of genetic bases and cultural elaborations in these higher levels of linguistic
30 structuring can best be done by comparing the extant languages and finding common denominators
31 not attributable to shared cultural ancestry, which contrary to linguistic orthodoxy are actually few
32 and far between (Evans and Levinson 2009, Levinson and Evans 2010). Notice that the picture just
33 sketched inverts the usual suppositions, which assume a genetically coded, fixed linguistic
34 structure, with variable cultural uses – far more plausible is a slow accumulation of the genetically
35 influenced motivations and contexts for language usage, making it possible to “outsource” much of
36 language structure to the newly evolved capacity for culture.¹⁰

37
38 Although we have stressed here the relative antiquity of modern language – we have after all argued
39 for at least a tenfold increase in time depth from the c. 50,000 years sometimes quoted (e.g.
40 Chomsky 2007; see also Klein 2009:648-649) – still, on an evolutionary timescale half a million
41 years is a flash in the pan. It pales beside the animal models sometimes appealed to by linguists,
42 like echolocation in bats (Teeling *et al.* 2005) or song in passerine birds (Christidis *et al.* 2002)
43 which both have origins over 50 mya. Language as we know it must then have originated within the
44 ~1 million years between *H. erectus* and the common ancestor of Neandertals and us. That is still a
45 remarkably short period to evolve a complex system and the implication must be that language
46 abilities were relatively rapidly cobbled together from preadapted cognitive and neurophysiological

¹⁰ This perspective is entirely compatible, pace a reviewer, with recent developments in generative theory where variation is relegated to peripheral processes.

1 structures.

2
3 A *third* possible consequence is that there may be ample scope for the interplay between population
4 genetics and linguistic diversification. Dediu and Ladd (2007) showed an association between the
5 frequency of certain genes involved in brain growth and development (*ASPM* and *Microcephalin*)
6 and the prevalence of tone languages, suggesting that slight differences in population genetics can
7 act as cultural “attractors”, making it slightly more likely that certain linguistic types will propagate
8 (Dediu, 2011). Since the variants of these genes associated with non-tonal languages seem to have
9 been absent from Neandertals¹¹, it is reasonable to assume that Neandertal languages were most
10 probably tonal. Such genetic biases would generally act as cultural attractors over relatively large
11 time periods, so the increased time-window for language history suggests that there may be
12 significant numbers of such effects yet to be discovered. A good place to start looking for them is
13 represented by the biasing effects the vocal tract could have on phonetics and phonology¹². Other
14 genes are known to have an effect on language and speech (e.g., *ROBO1*, *KIAA0319*, *CNTNAP2* or
15 *DCDC2* to name just a few) but we currently know too little about their functions and their variants
16 across human populations to fruitfully speculate about their possible role in biasing particular
17 directions in the cultural evolution of languages. Nevertheless, advances in understanding the
18 genetic influences on language and speech, coupled with the availability of ancient DNA, may
19 make it possible to speculate with more certainty about our ancestor's languages.

20
21 *Fourth*, if languages have much deeper historical roots than we have so far supposed, we need to
22 find some way to extend the reach of historical linguistics. The comparative method, the classic
23 way to demonstrate language relatedness, relies on lexical parallels or cognates whose signatures
24 are steadily eroded by sound and meaning changes. Consequently, most linguists believe that the
25 maximum reconstructed time-depth is about 10,000 years. Dunn *et al.* (2005, 2008) showed that
26 structural features of language can effectively mirror the information in the vocabulary, and may
27 potentially reach back 10,000 years or more where cognates have been lost. The method presumes
28 that on average structural properties of languages change less often than words, and this is probably
29 true: When changes of structure are reconstructed across the whole tree for large language families,
30 we find that individual structural features (like major word order changes) change on average
31 within a lineage just once in many thousands of years (Dunn *et al.* 2011). But whether hand-picked
32 core vocabulary (like the Swadesh list or the new Leipzig-Jakarta list) changes faster than structure
33 in general is still controversial (Greenhill *et al.* 2010). What one may hope is that some
34 combinations of structural features will prove so conservative that they will allow deep
35 reconstruction (Dediu 2011). We have recently shown that, by combining structural features with
36 information derived from other sources (in the form of language family trees) using Bayesian
37 phylogenetic techniques, it is seemingly possible to pick up ancient signals of relatedness across the
38 Bering Straits linking North-East Eurasian and American languages (Dediu & Levinson 2012).
39 Such links plausibly predate the loss of the land-bridge due to sea level rises c. 10,000 years ago,
40 and similar analyses using structural data also point to Pleistocene language connections in Island
41 Melanesia (Dunn *et al.* 2005) and Sahul (Reesink *et al.* 2009) predating the loss of other land
42 bridges at the same time.

¹¹ Only the ancestral allele of *Microcephalin* was found in the single individual genotyped by Lari *et al.* (2010) and also seems to be present in the individuals used by Green *et al.* (2010) for the draft Neandertal genome. The derived allele of *ASPM* is estimated as far too young (5800 years, 95% confidence interval 500-14100; Mekel-Bobrov *et al.* 2005) to have been present in Neandertals.

¹² This direction is currently investigated by a project led by the first author and there are already hints that there is intra- and inter-populations variation in components of the vocal tract (e.g., the hard palate) at least partly under genetic influences, and that this variation might indeed bias speech.

1
2 *Fifth*, the greater antiquity of language has important consequences for our theories of linguistic
3 diversity. Traditionally it has been supposed that the current linguistic diversity (c. 7000 extant
4 languages) offers a good basis for extrapolation of linguistic universals, or intrinsic constraints on
5 linguistic capacity. But recent developments in the computational phylogenetics of language
6 structure have revealed that structural change in languages is on average remarkably slow – on the
7 order of tens of thousands of years (Dunn *et al.* 2008, 2011). On the standard picture modern
8 humans left Africa in very small numbers not before, say, 70 kya, and perhaps as late as 50 kya. The
9 genetic bottleneck that has been detected and dated to about this time (Amos and Hoffman 2010)
10 implies a cultural bottleneck – just a handful of languages accompanied the first migrants. If all the
11 languages we currently have are the descendants of this small set (plus the stocks remaining in
12 Africa), then the diversity we now have does not adequately sample the “design space” of possible
13 languages at all (Evans and Levinson 2009). After all, language families like Indo-European can be
14 traced back ~9000 years (Atkinson and Gray 2006; Pagel 2009); so 6 or 7 such steps take us right
15 back to the great diaspora. Our 7000 languages then tell us a story of historical relatedness and not
16 much about the intrinsic limitations on the design space. The traditional goals of language typology,
17 namely discovering language universals, would then be misguided – the data would tell us very
18 little interesting about intrinsic constraints on possible languages.

19
20 However, some language families and linguistic features are very conservative (Dunn *et al.*, 2011;
21 Dediu 2011) and such slow rates of change seem unable to account for the current diversity
22 evolving since the expansions out of Africa. But if modern humans exiting from Africa interacted
23 and interbred with Neandertals (and later, on their way through Asia, with Denisovans), then their
24 contribution, we propose, might have shaped modern linguistic diversity. Neandertal (and
25 Denisovan) languages would have offered a reservoir of linguistic diversity, on which the ancestors
26 of our 7000 current languages may have drawn. Then the present-day languages would, to some
27 extent, sample a wider part of the possibility space for languages, drawing on the Neandertal
28 exploitation of that space over half a million years. At the same time, we have to remember that
29 those ancestors of modern humans who continued to inhabit Africa also enjoyed half a million years
30 of linguistic evolution.¹³

31
32 As we have seen, the two human lineages probably interacted, interbred, and borrowed culture.
33 There were numerous points and periods of contact, e.g. early in the Near East around 100kya, and
34 thereafter at different locations in Eurasia. Although material culture suggests this interaction may
35 have been mostly unidirectional, from modern humans to Neandertal groups, Neandertals no doubt
36 had many useful concepts and techniques for exploiting their boreal habitats. Assuming again, as
37 we have argued, that the two groups had similar speech and languages, four speculative scenarios
38 can be imagined:

39
40 **Scenario 1:** *Language shift: modern humans adopted Neandertal languages.* This is not likely,
41 since in general the bearers of superior technology get aped and not the other way around.
42 However, there are exceptions, for example the adoption by previously Indo-European farmers of a
43 Saami language spoken by hunter gatherers, namely Finnish (Sajantila *et al.* 1996). If this
44 happened, there should be a radical discontinuity between the languages of Africa and the
45 languages of the rest of the world, and no such discontinuity has yet been found (Cysouw and

13 These ideas need rigorous testing through computer models as it is not at all clear how these 500kya of linguistic evolution play out in various demographic scenarios. Conceivably, a stable population of large size will produce a quite different pattern of linguistic diversity to a set of many small individually fleeting populations in contact.

1 Comrie 2009).

2

3 **Scenario 2:** *Language extinction: Neandertals interacted little and when they did they adopted*
4 *modern human languages.* On this scenario the technologically superior and demographically more
5 numerous modern humans simply swamped Neandertals' languages and culture. In this case there
6 should be no particular differences between African languages and those of the rest of the world,
7 and there would have been limited time depth for linguistic diversification and exploration of the
8 possibility space for languages as discussed above.

9

10 **Scenario 3:** *Pidginization: a new type of language is born by radical simplification.* Pidginization
11 is associated with colonization and rapid expansion of trade networks. Two human groups, in
12 symmetrical relation, find a radical new solution to coexistence, dismantling two languages and
13 rebuilding a third from the bits. This scenario does not seem consistent with the low level of contact
14 in hunter-gatherer groups, nor with the archaeological record, which shows imported tool types in
15 the Neandertal sites but not a radical rebuild of existing assemblages.

16

17 **Scenario 4:** *Sustained low intensity contact: a moderate exchange of lexicon and structure.* This
18 scenario is the most likely in our view. The two lineages would have been in protracted contact (as
19 they were in the Middle East for up to 50,000 years). Technological and material exchange was
20 mostly from modern humans to Neandertals, and the language borrowings may have followed suit.
21 But material culture and language often part company – in Melanesia, for example, the technology
22 and most of the material culture is uniform in both those societies speaking the more recently
23 introduced Austronesian languages and those speaking the indigenous Papuan languages. It is quite
24 probable that the Neandertals had both material and immaterial cultural tricks of considerable value
25 for cultural adaptation to the new non-African environments (as they presumably did on the genetic
26 side; Hawks and Cochran 2006), and that these may have induced linguistic loans along with
27 language structure.

28

29 Evidence related to these different scenarios comes from the archaeological data already mentioned,
30 which points to e.g. extensive overlap between Neandertal and modern human populations in
31 Northern Europe, with consequent borrowing of material culture (Hublin et al 2012). But a more
32 directly linguistic way to test these scenarios is to look for subtle structural differences between the
33 languages of Africa and the rest of the world, as any such finding might point to remnants of
34 Neandertal languages. For example, we could compare structural profiles of languages in Africa
35 and outside it using pattern detection techniques such as Support Vector Machines, or by looking at
36 the distribution of structural differences in geographic space. Similarly, differences between Papuan
37 and Australian languages, on one hand, and the other languages on the other, might offer a glimpse
38 of an outcome of the interaction between human and Denisovan languages: recently, David Gil
39 (2011) suggested that features related to lower grammatical complexity present in the languages of
40 the “Mekong-Mamberamo” linguistic area (from mainland SE Asia through most of Indonesia and
41 into the western half of New Guinea) could be a remnant of contact with Denisovans. This
42 suggestion is based on McWhorter's (2008) speculation that the simplification of the Austronesian
43 languages on the island of Flores could be due to early contact with *H. floresiensis*. Realistic
44 computer models of these particular encounters might help us better quantify what are the most
45 probable consequences for today's languages and provide clear and testable predictions of these
46 hypotheses. Finally, using the rates of structural change mentioned above, it is in principle possible
47 to construct forward models that attempt to generate current linguistic diversity within the c. 60k
48 years since the last great exodus of modern humans from Africa, and to test whether it is necessary
49 to draw on ancient reservoirs of linguistic diversity already present in Eurasia.

1

2 **5. Conclusions**

3

4 In this paper, we have tried to review the evidence supporting the claim that Neandertals,
5 Denisovans and contemporary modern humans shared a similar capacity for modern language,
6 speech and culture. Furthermore, we argued that regarding these lineages as different species is
7 unhelpful, and that their admixture probably shaped present-day genetic and linguistic diversities.
8 Moreover, we propose an approach which might allow us to increase the focus of scientific inquiry
9 into the deep past of linguistic diversity, by comparing present-day African and non-African (and
10 possibly Papuan and Australian to non-Papuan non-Australian) structural linguistic distributions.
11 We need to fully grasp the implications of the fact that human evolution (ancient, recent and
12 current) is a reticulated process, which has the consequence, among others, that we have to regard
13 language as a very old cultural evolutionary process in which both vertical and horizontal processes
14 are essential contributors. On this background of shared capacities, understanding the relatively
15 small differences between modern humans, Neandertals and Denisovans will help shed more light
16 on the nature and evolution of speech and language.

17

18 The antiquity of modern language and speech capacities, going back to at least the last common
19 ancestor of Neandertals, Denisovans and modern humans some half a million years ago, raises new
20 and interesting questions concerning the nature of the linguistic design space, the relationship
21 between biological and cultural evolution, and the time frame for the emergence of modern human
22 traits, and language in particular.

23

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28

29

30 **References**

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Figure 1: A graphical summary of our proposal. Dates, lineage names and genealogical relationships between them are tentative. 'Tools' lists the main toolkits in use, 'Speech' describes the main evidence for advanced vocal capacities and 'Communication' describes the inferred communication systems and their properties, as argued in the paper. The arrows represent admixture.

Figure 1.TIFF

