Is a holistic protolanguage a plausible precursor to language?

A test case for a modern evolutionary linguistics

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Abstract

If protolanguage was a holistic system where complex meanings were conveyed using unanalysed forms, there must be some process (*analysis*) which delivered up the elements of modern language from this system. This paper draws on evidence from computational modelling, developmental and historical linguistics and comparative psychology to evaluate the plausibility of the analysis process. While some of the criticisms levelled at analysis can be refuted using such evidence, several areas are highlighted where further evidence is required to decide key issues. More generally, the debate over the nature of protolanguage offers a framework for developing and showcasing a modern, evidence-based evolutionary linguistics.

Keywords: protolanguage, segmentation, analysis, evidence

Biographical note

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1 Introduction

Humans have language. It is hypothesised that the common ancestor of chimpanzees and humans did not. Evolutionary linguists therefore have to explain how the gap between a non-linguistic ancestor and our linguistic species was bridged. It has become common to invoke the concept of a *protolanguage* as a stable intermediary stage in the evolution of language: "[t]he hypothesis of a protolanguage helps to bridge the otherwise threatening evolutionary gap between a wholly alingual state and the full possession of language as we know it" (Bickerton, 1995, pp. 51).[1]

What was protolanguage like? Under the *holistic* account, (see, e.g., Wray, 1998), protolanguage was a system in which individual signals, lacking in internal morphological structure, conveyed entire complex propositions. The transition from a holistic protolanguage to language occurred when holistic utterances were broken down to yield words and constraints on their combination. This process is known as *analysis*, also sometimes referred to as segmentation (Wray, 1998) or fractionation (Arbib, 2005).[2] In order for holistic protolanguage to be a plausible *precursor* to modern language, it must be possible to get from such a protolanguage to language: the analysis process must be shown to be plausible.

In the context of a broader assault on holistic protolanguage, Tallerman (2007) provides a thought-provoking critique of the analysis process. According to Tallerman, analysis suffers from the following defects:[3]

1. Analysis requires cognitive resources greater than we can expect early hominids to exhibit.

2. Analysis would be blocked by counter-examples to any nascent generalisations.

3. Analysis forces us to posit fundamental discontinuities between prehistoric and contemporary processes of language change.

In Sections 3–5 I consider the evidence available to evaluate each of these criticisms. This process provides a useful framework in which to explore the kinds of evidence we can use to evaluate theories of protolanguage in particular, and the evolution of language more generally. It is often claimed that evolutionary linguistics suffers from a paucity of evidence:

> "To enter [the field] costs little: you can't do experiments, so no expensive equipment is

required (. . .). It's still a pencil-and-paper field" (Bickerton, 2007, pp. 524)

I will argue that, on the contrary, there is a wealth of empirical evidence which evolutionary linguists can draw on to constrain and inform theory: many relevant experiments have already been done and, importantly, any serious attempt to evaluate any theory of the evolution of language is likely to suggest further experiments which remain to be done. In this paper I will use evidence from comparative psychology, developmental and historical linguistics and computational modelling to evaluate the plausibility of a transition from a holistic protolanguage to language via analysis, and identify several key areas where further evidence is needed to discriminate between competing claims. This provides an illustration of the more general process of evaluating theories of the origins and evolution of language. A modern evolutionary linguistics should draw on existing data from all these areas, but more importantly, use methodologies from these fields to actually go out and test hypotheses from the literature.

2 Learning by segmentation and the analysis process

Analysis is the process by which holistic utterances are broken down over historical time into component words plus rules which govern their combination. Wray (1998) describes a scenario under which chance co-occurrences of meaning and form between holistic utterances lead protolanguage learner/users to segment out words, leaving behind a residual template. Wray (1998, pp. 55–56) illustrates this process with a hypothetical example of segmentation, based around the following two signs of a holistic protolanguage — as in Wray (1998), signals are given as sequences of phonemes, semantics are given in English.

(1) /mɛbita/ ⟷ "give her the food"

(2) /kamɛti/ ⟷ "give her the stone"

Wray suggests a scenario where a segmenting learner notes and exploits the partial regularity in (1) and (2), namely that a common element of signal (/mɛ/) corresponds to a common element of meaning ("her").[4] This coincidence of meaning and form occurs by chance in the holistic protolanguage providing signs (1–2). The segmenting learner notes this regularity, and segments out a morpheme which captures it, leaving behind a residual unanalysed template. Schematically, the internal representation of the partiallysegmented protolanguage would be:

X/bita/ $\longleftrightarrow$ "give X the food"

/ka/X/ti/ $\longleftrightarrow$ "give X the stone"

/mɛ/ $\longleftrightarrow$ "her" (in contexts where it substitutes into position X)

Subsequently, the individual who has discovered this structure may produce novel utterances which exploit this regularity, systematically using /mɛ/ to convey the meaning "her". The accumulation of these segmentations, and their exploitation by segmenting learners, leads to the historical process of analysis, whereby an initially unstructured holistic system comes to exhibit structure based on words and constraints on their combination.

Have we any concrete reason to believe that a holistic protolanguage will evolve into a system with words and rules in a population of individuals learning in this way? Human intuitions on these kinds of complex historical processes tend to be poor. In cases such as these, computational and mathematical models provide a valuable tool for conducting "opaque thought experiments" (Di Paolo, Noble, & Bullock, 2000), or mechanically working through the macroscopic consequences of a well-specified set of microscopic assumptions (e.g. assumptions about the processes of learning).

Kirby (2002) provides a model which demonstrates that cultural transmission in a population of segmenting learners can result, under certain plausible transmission conditions, in a transition from holism to a compositionally-structured linguistic system.[5] A number of such models demonstrating this process exist (see Kirby, Smith, & Brighton, 2004, for review): similar results have been shown for different models of language learning (e.g. a heuristic grammar inducer in Kirby, 2002; an associative network model in Smith, Brighton, & Kirby, 2003), different treatments of population (purely vertical transmission in e.g. Kirby, 2002; purely horizontal transmission in Batali, 2002), and different treatments of the grounding of language in use (no grounding of meaning in e.g. Kirby, 2002; grounding in Vogt, 2005).

The wealth of formal modelling in this area serves two functions. Firstly, each model provides proof of concept for the analysis process. Secondly, the diversity of modelling approaches suggests that the analysis process is at least somewhat robust, having been demonstrated under a wide range of assumptions about how learning works, how populations are structured, and how meaning is constructed. This breadth of approaches is significant — while we can debate the relevance of the assumptions made in one model, repeated demonstrations of the same phenomenon in a range of models provides converging evidence that the process we are dealing with is not completely dependent on certain key assumptions. Without this diversity of coverage, we need to either be more cautious in extrapolating from modelling results, or have greater confidence in the key assumptions made in our models.

3 Criticism 1: Can *Homo* analyse?

Computational models show that analysis can in principle deliver up words and rules from a holistic protolanguage. But how cognitively demanding is the type of learning underpinning analysis? Can modern humans do it? If so, we might accept that analysis could have begun with the advent of *Homo sapiens*. Could earlier hominids (e.g. *Homo erectus*, tied to the inception of the analysis process by Tallerman, 2007) do it?

3.1 Can modern humans analyse?

There is strong developmental and historical evidence that modern humans do segment and analyse. Tallerman herself points towards a contemporary example of segmentation in action: language acquisition. Children successfully segment out words and constraints on their combination from instances of language use which must be treated, at least initially, as unanalysed meaning-form pairs (see, e.g., Tomasello, 2003). Indeed, Wray's initial account of segmentation was explicitly motivated by Peters's (1983) account of language learning. The historical literature also suggests that structure can be introduced into words where none was previously present, through processes of *back-formation* and *reanalysis* (e.g. back-formation of the verb "peddle" from the noun "peddler" due to the coincidence between the "er" ending of the noun and the derivational affix "-er", productive elsewhere in the language: Simpson & Weiner, 1989).

Tallerman, following Johansson (2005), raises the important caveat that children segment a system of form-meaning pairs which contains abundant evidence of structure ripe for segmentation. Similarly, historical reanalysis is dependent on structure already present elsewhere in the language (e.g. a productive affix). In contrast, the analysis process requires segmentation in situations where apparent structure is sporadic and not generated by any underlying rule. While it is therefore safe to argue that humans are capable of segmentation and analysis under modern conditions, whether a modern human learner would also segment and analyse a holistic protolanguage is less clear.

There is in fact some evidence to support Tallerman's contention that segmentation during acquisition (and the related historical processes) is dependent on the presence of a large body of confirming evidence for this segmentation. Type frequency (the number of verbs participating in a particular inflectional paradigm) is a key determinant of the productivity of inflectional paradigms (Bybee, 1985, 1995). This relationship between type frequency and productivity is readily explicable under a segmenting model of learning: high type frequency provides precisely the circumstances required under the segmenting model for generating structural abstractions, specifically a varied range of fillers capable of slotting in to a particular template. However, the fact that productive abstractions seem to require high type frequency suggests that infrequently-occurring chance correspondences (such as we might expect to find in a holistic protolanguage) would not lead to segmentations which can be productively applied. Child-directed speech also appears to be well-adapted to a segmenting learner who requires abundant evidence for segmentations (Cameron-Faulkner, Lieven, & Tomasello, 2003), being dominated by a small number of templates (e.g. "What's X doing?", "That's a X", "Are you going to X?") with a wide range of items slotting in to those templates.

While this is rather suggestive, it is unclear what the boundary conditions on segmentation are: how little evidence does a modern human require to make a segmentation? If that evidence must be abundant, as Tallerman suggests, we should be sceptical as to the likelihood that analysis could get off the ground based on a small number of chance correspondences. While the evidence from morphology and child-directed speech is suggestive, a more direct means of addressing this crucial question is desirable. The most straightforward way of resolving this issue would be to conduct a relatively simple psycholinguistic experiments similar to those of Gómez (2002). Gómez demonstrates experimentally that templates which apply to highly variable fillers is more readily learned by adults and children than a template which appears in more stereotyped circumstances, applying only to a small number of fillers. A similar methodology could be applied to explore whether fillers for a given template have to be highly variable for the filler-template representation to actually be internalised.

3.2 Could earlier hominids analyse?

Although the all-important boundary conditions for segmentation remain mysterious, there is pretty good historical and developmental evidence that modern humans can do segmentation and analysis in at least some conditions. Would earlier *Homo* have had similar capacities to modern humans?

Tallerman is deeply sceptical:

> "words will never appear out of formulae unless the hominids using holistic protolanguage have both the necessary motor control and the neural capacity to recognise phonetic strings … how could these abilities exist prior to the language faculty itself?" (Tallerman, 2007, pp. 595)

How can we know what early *Homo* was capable of in terms of segmentation and analysis? While we might note that the ability to spot co-occurrences of meaning and form across two signs can be realised by fairly rudimentary learning devices (e.g. an associative network, Smith et al., 2003) or learners with fairly limited capacities of attention and memory (e.g. children), the more general question remains of how to evaluate claims about the cognitive capacities of extinct species.

Saffran, Aslin, and Newport (1996) investigate the process whereby language learners break up a continuous stream of sounds into words. This mechanism could be used by a segmenting learner to identify strings of syllables (or phonemes) which tend to co-occur across utterances, such sequences being candidates for segmentation. They found that 8 month old infants were able to use simple statistical properties of the input (syllable transitions within words are relatively predictable relative to syllable transition between words) to segment out words. Crucially, the same capacities have been shown by Hauser, Newport, and Aslin (2001) to be present in cotton-top tamarins (*Saguinus oedipus*, last common ancestor with humans around 40 million years ago: Rosenberger, 1992). Although this doesn't show that the capacity to analyse is within the capabilities of non-human primates, it is at least an indication that some of the capacities (e.g. "the neural capacity to recognise phonetic strings"), are found in non-linguistic species. It also highlights an important body of work which can go some way toward illuminating the cognitive capacities of early *Homo*: careful comparative work assessing the relative capacities of humans and non-humans, in an effort to construct an evolutionary taxonomy of cognitive capacities (see, e.g., Hauser, Chomsky, & Fitch, 2002; Fitch & Hauser, 2004; Gentner, Fenn, Margoliash, & Nusbaum, 2006; see also Fitch, 2005 for review).

3.3 Can *Homo* analyse: a summary

Humans can uncontroversially segment and analyse in the modern linguistic context. There is, however, some suggestive evidence that this requires, or is at least facilitated by, abundant evidence for the existence of productive generalisations. Given that analysis of holistic protolanguage requires segmentation on the basis of more sporadic data, the limits of the human capacity to segment must be probed before we can decide whether holistic protolanguage can survive Tallerman's criticism. Similarly, we lack the body of comparative work necessary to establish whether earlier hominids possess the same powers of segmentation and analysis as modern humans, but there is at least suggestive evidence that components of these capacities may not be unique to humans.

4 Criticism 2: Can analysis tolerate counter-examples?

Segmentation involves identifying and exploiting chance co-occurrences of form and meaning across two or more holistic utterances. Tallerman's second criticism of the analysis process hinges on exceptions to these co-occurrences:

> "logically, similar substrings must often occur in two (or more) utterances which do *not* share any common elements of meaning at least as many times as they occur in two utterances which *do* share semantic elements. . . . The holistic scenario is, therefore, weakened by the existence of at least as many counterexamples as there could be pieces of confirming evidence for each putative word." (Tallerman, 2007, pp. 597–598)

There are two claims here: 1) counter-examples will exist (or will, in fact, outnumber confirming examples); 2) counter-examples prevent segmentation and analysis. If both these are true then we might indeed be forced to reevaluate the plausibility of the analysis process.

4.1 Claim 1: the existence of counter-examples

As highlighted by Tallerman, there are two possible types of counter-example to the generalisation that element of meaning μ co-occurs with element of signal σ:

Type 1: utterances with meaning μ do not have σ in their signal

Type 2: σ occurs in utterances which do not have meaning μ

Tallerman's suggestion that there is some logical necessity that counter-examples will outnumber confirming cases for any possible segmentation is too strong: the number of counter-examples to a segmentation depends on the set of utterances under consideration, and cannot be deduced *a priori*. What aspects of the structure of a protolanguage determine the likely number of confirming cases for a particular candidate segmentation, and the number of counter-examples to those segmentations? I will provide a simple illustration here, focusing on Type 1 counter-examples, of how modelling can be used to probe Tallerman's intuition in a slightly more rigorous fashion.

If the probability of two randomly-selected signs from a protolanguage (of S signs) sharing a semantic element μ is P_μ and the probability of two signs sharing an element of form σ is P_σ, then the number of confirming cases for some arbitrary generalisation pairing μ with σ is $P_\mu.P_\sigma.S$. The number of Type 1 counter-examples is $P_\mu.(1-P_\sigma).S$ and the ratio of confirming cases to Type 1 counter-examples is given by $P_\sigma/(1-P_\sigma)$. Similarly, the ratio of confirming cases to Type 2 counter-examples is $P_\mu/(1-P_\mu)$. In other words, if two randomly selected signs are more likely to share signal element σ than not, then confirming cases for segmentation involving σ will outweigh Type 1 counter-examples, and if two signs are more likely to share semantic element μ than not then confirming cases will outweigh Type 2 counter-examples. Note that S, the size of the protolanguage, impacts on the absolute number of confirming and counter-examples, but not the ratios.

We therefore need to quantify P_μ and P_σ. Focusing on P_σ: assume that signals in a protolanguage are strings of uniform length L, consisting of distinctive elements (phonemes, say, or syllables) drawn with uniform probability from an inventory of size E. There are $L-(l-1)$ substrings of length l contained in a string of length L, and the probability of a string of length l being generated by random selection with replacement from E is $(1/E)^l$. The probability that a string j (of length L) contains *no* occurrences of substring i (of length $l \leq L$) is

(3) $$(1 - P_\sigma) = P(i \notin j) = \left[1 - \left(\frac{1}{E}\right)^l\right]^{(L-(l-1))}$$

i.e., $P(i \notin j)$ is simply the probability that substrings other than i occupy each of the substrings of j. The probability that i occurs at least once in j is therefore

(4) $$P_\sigma = P(i \in j) = (1 - P(i \notin j))\,.$$

Figure 1 shows the ratio of confirming cases to Type 1 counter-examples calculated using this equation, for various values of L, l and E. A similar analysis could be performed for P_μ, in order to relate aspects of semantic structure to the ratio between confirming cases and Type 2 counter-examples. Note that (contrary to Tallerman's strong claim) Type 1 counter-examples do not always outnumber confirming cases — rather, the ratio of confirming cases to counter-examples depends on L, l and E. However, a weaker interpretation of Tallerman's intuition is borne out: under the (reasonably plausible) assumptions that utterances are relatively short and do not consist of a very small number of segments, counter-examples should, on average, outnumber confirming cases. The counter-example problem is particularly marked if we assume that analysis requires matching of longer substrings ($l > 1$), at which point counter-examples tend to outnumber confirming cases for all but the most contrived of cases.

4.2 Dealing with counter-examples

If counter-examples are likely to exist in abundance, it therefore becomes crucial to determine how the segmenting learner/user deals with those counter-examples (see also the discussion in Wray, 2000). There is in fact strong evidence that children will happily discount counter-examples to regularities suggested by the data they learn from. Consider the acquisition of the past tense marker "-ed" in English. In the terms used for analysis in Section 2, learners of English are exposed to datasets containing items such as (5–8).

(5) /ðekɪld/ $\longleftrightarrow$ "they [past] kill"

(6) /wipled/ $\longleftrightarrow$ "we [past] play"

(7) /ʃikem/ $\longleftrightarrow$ "she [past] come"

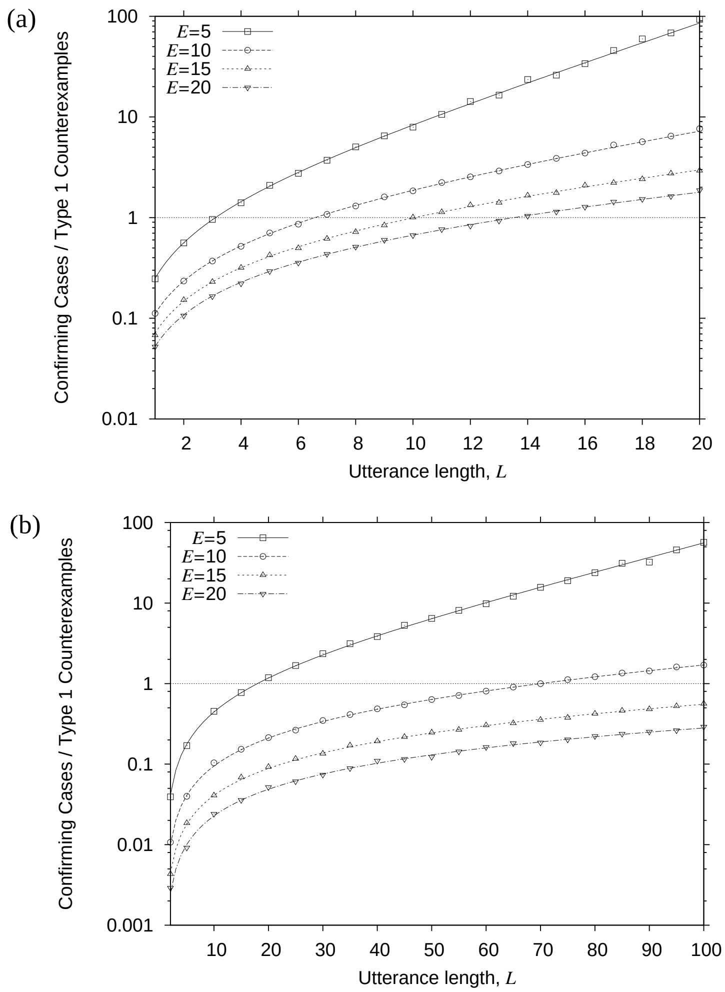

Figure 1: Lines give ratio of confirming cases to Type 1 counter-examples ($P_\sigma/(1-P_\sigma)$) for various values of L and E, calculated by equation. Figure (a) shows the ratio for matching substrings of length 1 ($l = 1$), (b) is for the case $l = 2$. The one-to-one ratio of confirming cases to counter-examples is given by the horizontal line. Points are results from Monte Carlo simulation: each point represents the ratio of substring inclusion to non-inclusion for a sample of 10000 pairs of randomly generated strings of length L and substrings of length l, with alphabet E.

(8) /ɪtsrɛd/ ⟷ “it [pres] be red”

In spite of counter-examples of the type exemplified by (7–8), speakers of English eventually arrive at a grammar of the form

/ðekɪl/X ⟷ “they TENSE kill”

/wiple/X ⟷ “we TENSE play”

/ʃikem/ ⟷ “she [past] come”

/ɪtsrɛd/ ⟷ “it [pres] be red”

-/d/ ⟷ “[past]”

This indicates that counter-examples are not a total block on generalisations of this sort. Quantifying the *ratio* of confirming cases of past-tense “-ed” to counter-examples is not straightforward. However, a simple illustration is possible if we focus on Type 1 counter-examples involving irregular verbs like /kem/ (which share the same element of meaning with regulars, namely past tense, but lack the “-ed” suffix). It is well established that regular verbs outnumber irregulars in the lexicon (see the earlier discussion on type frequency), but that irregular verbs are used more frequently (Francis & Kucera, 1982). For example, 961 of the 1089 most frequently occurring verb lemmas in a 100 million word corpus of written and spoken English (Leech, Rayson, & Wilson, 2001)[6] form their past tense using the “-ed” suffix. This constitutes the evidence-base for segmenting out the “-ed” suffix[7], with the remaining 128 verb lemmas which form their past tense in some other fashion constituting Type 1 counter-examples. If we look at the frequency with which those lemmas occur, we find that counter-examples actually outnumber confirming cases: confirming lemmas for “-ed” occur 59231 times per million words, counter-example lemmas occur 99528 times per million words.

Counter-examples are therefore likely to outweigh (or at least occur with a frequency on the same order of magnitude as) confirming cases for a generalisation that all speakers of English make. Furthermore, children not only make this generalisation despite those counter-examples, but directly apply the generalisation to cases which explicitly contradict the data they were exposed to, producing forms such as “comed” (see, e.g., Brown, 1973). While this over-generalisation is later corrected, it does demonstrate that counter-examples cannot be a total block to generalisations at all times, for human language learners. As such, it provides some evidence against the claim that counter-examples will necessarily prevent segmentation and analysis.

There is also evidence that counter-examples do not block processes reminiscent of segmentation/analysis on a historical timescale. For example, the reanalysis in Middle English of sequences such as “a nadder” to “an adder” (also the reverse “an ewt” to “a newt”, both examples from the OED: Simpson & Weiner, 1989) presumably occurred in the face of counter-examples (“thenaddre”, “threenaddres”, “the ewt”, “three ewts” etc). In more general terms, it has long been acknowledged that the kinds of reanalyses occurring over historical time take place in the face of counter-examples to those reanalyses. Sturtevant’s paradox (Trask, 1996, pp. 108) states that sound change is regular but produces irregularity, whereas *analogy is irregular but produces regularity*. In other words, analogy as a historical phenomenon occurs in a rather sporadic fashion: unmade analogies constitute “counter-examples” to the regularity embodied in the analogy.

4.3 Counter-examples: a summary

Tallerman’s second criticism looks considerably weaker than her first: while a simple model suggests that her intuition that counter-examples are likely to be frequent is correct, there is developmental and historical evidence to suggest that, at least for modern humans, counter-examples are not a total barrier to segmentation and analysis. The subsidiary question — what did earlier *Homo* do — is currently unanswered, and would require comparative studies of humans and non-human treatment of counter-examples.

5 Criticism 3: Does analysis violate the uniformitarian assumption?

A useful assumption to make is that of *uniformity of process*: the processes observed to be operating in the world today also pertained in the past (Lyell, 1830; Gould, 1965). This assumption allows us to reason about past events based on present-day evidence. Tallerman’s final criticism is that analysis-based accounts require us to abandon uniformity of process: modern-day holistic utterances don’t behave as prehistoric holistic utterances supposedly do, specifically, they don’t break down into their component parts to produce new words. This criticism is perhaps the most thought-provoking of those discussed in this paper, and raises a crucial evidentiary issue for the protolanguage debate: to what extent do we expect the processes and mechanisms of prehistoric language change (cultural evolution leading to the genesis of linguistic structure) to be the same as those driving acquisition and change in the present day? Much of the discussion in this paper reflects the assumption that we should find uniformity of mechanisms and processes.

Tallerman's main point is that words don't seem to be created by analysis of holistic utterances:

> "We have a very good idea where [for example] grammatical morphemes come from in fully-fledged language: they are formed from lexical morphemes, specifically from nouns and verbs, via the bundle of processes known as *grammaticalization* ... The null hypothesis is that the same processes were at work in the earliest forms of language ... to propose a holistic strategy involving fractionation is to ignore the known processes by which words come into being in language" (Tallerman, 2007, pp. 596)

The extent to which we should expect uniformity of process at all is actually rather more complex than Tallerman admits. Are the mechanisms of acquisition and use applied by early *Homo* the same as those used by *Homo sapiens*? It is conceivable, as argued by Tallerman (see Section 3), that early *Homo* was an entirely different kind of learner, in which case we might in fact expect to see non-uniformity of process. However, for accounts which tie the inception of the analysis process to *Homo sapiens*, or assume that earlier *Homo* resembles modern humans in these respects, the uniformity question must be directly addressed.

Contrary to Tallerman's implication, grammaticalisation and segmentation/analysis operate side by side in contemporary language. As discussed in Section 3, human mechanisms of acquisition and use lead to segmentation during language learning and analytic historical processes such as back-formation and reanalysis. Simultaneously, the same mechanisms of acquisition and use lead to grammaticalisation as a historical process. Humans therefore embody a single system of acquisition/use which underpins both analysis and grammaticalisation, apparently such different phenomena: in other words, *a uniform process of learning and use* leads to markedly different developmental and historical phenomena (segmentation by learners, grammaticalisation by populations of such learners) despite an underlying uniformity of process. I offer a speculative hypothesis: the same be shown to be the case on a population level, such that differences in the nature of a population's language (i.e. the extent to which it has undergone analysis) lead to different predominant patterns of change, with a switch from analysis to grammaticalisation emerging as a language develops from a holistic protolanguage to a system with words and rules. This is an open challenge to the modelling community, and one which requires significant work to explore. Most models of analysis, quite reasonably, stop where analysis stops (and the words and rules stage), and would require significant extension to also model grammaticalisation. However, early work on models of segmenting learners where populations of such learners exhibit grammaticalisation is underway (see, e.g., Hashimoto & Nakatsuka, 2006).

The uniformity of process critique constitutes the strongest objection to holistic protolanguage accounts, in that such accounts appeal to phenomena other than those observed in the present day to explain the creation of words. However, there is no fundamental incompatibility between segmentation and grammaticalisation — the fact that both processes co-exist in human populations (segmentation during acquisition, grammaticalisation on a historical timescale) show that a single mechanism of language learning and use can underpin both phenomena. The challenge for proponents of holistic protolanguage is to provide a coherent account of how the predominant historical pattern could change from analysis to grammaticalisation — unless this can be demonstrated, Tallerman's criticism based on uniformity of process stands as a serious problem for holistic accounts.

6 Conclusions

In this paper I have used evidence from four sources to evaluate some specific claims about the evolution of language. Formal modelling allows us to test our understanding of the linkage between properties of individuals and properties arising from the interaction of such individuals. Developmental and historical data allows us to explore the details of modern-day language learning, and the macroscopic consequences of those processes: a real-world model of language evolution. Finally, comparative data can be used to attempt to pin down the likely cognitive capacities of early *Homo*.

These sources of evidence suggest that Tallerman's second criticism can probably be rejected, at least in its strongest form. While her intuition that counter-examples tend to outnumber confirming cases was broadly correct, there is strong evidence from developmental and historical cases that segmentation and analysis can proceed in the face of significant numbers of counter-examples. However, her other two criticisms highlight areas in which further research is required. The resolution of her first criticism requires us to understand how dependent the human capacity for segmentation is on a large body of evidence for those segmentations, as provided by the modern context of language learning. Resolving her third criticism requires a new body of modelling work, which is at a very early stage, which allows us to explore the relationship between the learning process and historical outcomes of the repeated application of those processes to linguistic systems at different stages in their development.

The protolanguage debate provides a fascinating test case for the development of evolutionary linguistics: it has the notable advantage that the opposing viewpoints are clearly stated, open to scrutiny, and pugnaciously defended. As such, it constitutes an excellent domain to debate what we think a modern evolutionary linguistics should look like. Is it a paper and pencil field, where theories stand and fall on their aesthetic appeal or economy of concept? Or is it one where evidence counts: where we identify the relevant experiments which have been and should be done, and proceed accordingly? I regard the latter approach as the only sensible one to take if we hope to make progress in our understanding of the origins and evolution of language.

7 Acknowledgements

Kenny Smith was supported by a Postdoctoral Research Fellowship from the British Academy. He thanks Andrew Smith and the four annonymous reviewers for comments, and other members of the LEC for insightful remarks during the development of the arguments presented herein.

Notes

[1]I will focus here on for multi-stage theories see, e.g., (Jackendoff, 2002; Smith, 2006).

[2]I will use “analysis” to refer to the historical process, and “segmentation” to refer to individual learning processes which lead to analysis.

[3]These three criticisms represent only a small subset of those presented in a detailed and useful paper.

[4]Note that this account of segmentation assumes that both meaning and form have some some similarity structure capable of being exploited by analysis, which is in itself worthy of explanation. However, analysis is not intended to be an explanation for the origins of such structure.

[5]There are alternative processes that can lead to the transition from holism to compositionality. For example, De Beule and Bergen (2006) provide a model where compositional utterances out-compete holistic alternatives due to language learner/users preferentially utilise communicatively successful utterance. Nowak, Plotkin, and Jansen (2000) make a similar point based on competition between speakers of holistic and compositional grammars, rather than competition between utterances within speakers. This paper focuses on analysis via segmentation, rather than analysis via this alternative mechanism.

[6]Specifically: Leech et al. (2001) provide a frequency list of verbs by lemma (List 5.2, downloadable at http://www.comp.lancs.ac.uk/ucrel/bncfreq/flists.html). This lists all 1112 lemmas which occur with a frequency of 10 words per million or more in their corpus. Modals (will, would, can, could, may, should, must, might, going, shall, ought, let’s) and lemmas with both irregular and regular past tenses or no clear past tense (learn, cost, born, lean, smell, spell, in, speed, bid, quit, strive) were removed from this list to give the 1089 lemmas discussed above.

[7]I will ignore the fact that these confirming cases will be realised as one of several allomorphs — this means that the figures give here actually underestimate the number of counter-examples. I will also assume that all verbs occur in the past tense with probability proportional to their lemma frequency.

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