LETTER TO THE EDITOR

Meaning as Use: Transmission Fidelity and Evolution in NetNews

1. Introduction

Gatherer & McEwan (1998) respond to our article (Pocklington & Best, 1997) with several apparently serious criticisms, concluding that our foray into cultural transmission theory is fundamentally flawed. Here we deal with each of their criticisms, in most cases by restating more precisely our model and claims. First we will outline some of the errors in their interpretation of our model and results. The bulk of their criticisms arise, we suspect, from the low fidelity transmission of ideas from our original paper. This has caused a misunderstanding of our description of units of selection. Second, we deal with some of their particular methodological criticisms. While some of their ideas might promote a more general approach to cultural evolution, none of them impinge on the validity of the particular results we report. A third source of disagreement is their differing conception of evolution and their anti-reductionist stance. While we leave for others a debate as to when an holistic approach offers a satisfactory addition to scientific reductionism, we here present our argument for the utility of rigorous replicator-based reductionism. Finally, we claim that unless they are willing to place their alternative framework in a concrete form and empirically demonstrate the coherency of their putative units of selection, their arguments for a coarser grained level of analysis are tenuous.

2. The Appropriate Unit of Selection in NetNews Discourse

Gatherer & McEwan claim that we conjecture that "words are the meme level". They state that, "There is no *a priori* reason to believe that the word is a more likely unit of selection than more fundamental textual elements such as phonemes, or lengthier constructions such as sentences or clauses ... However, without justification, Pocklington & Best then conjecture that words are the meme level, and choose to apply their Latent Semantic Indexing (LSI) technique to words alone." (Gatherer & McEwan, 1998).

We agree that the word is not an appropriate unit of selection. In previous investigations we concluded that individual words in NetNews are not, in fact, useful units of selection. We have never made a claim that words are memes or that words themselves are effective units of selection. Instead, we introduce the concept of the unit of selection as something that must be discovered in the corpus itself. We argue that,

"The appropriate units of selection will be the largest units of socially transmitted information that reliably and repeatedly withstand transmission" (Pocklington & Best, 1997).

It seems clear that culture is composed of a variety of replicating structures at varying levels of complexity. The Latent Semantic Indexing (LSI) technique we use allows us to distill out of the discourse one class of potentially relevant replicating structures, namely collections of words used together. We claim that,

"We have developed an analytic technique to detect units of selection within a corpus of texts. These units or cultural replicators will be sets of words which repeatedly co-occur. We argue that the repeated co-occurrence of words across texts indicates *replication of the concepts signified by those word combinations*. These replicating word combinations are taken to be units of selection as they fulfil the criteria of repeatable, reliable

replication." (Pocklington & Best, 1997, emphasis added).

These replicating word sets are given a vector representation we call the term-subspace. We go on to state that,

"These term-subspaces describe a set of semantically significant associative patterns in the words of the underlying corpus of documents; we can think of each subspace as a conceptual index into the corpus. *It is these term-subspaces which make up our replicators and are our putative units of selection*." (Pocklington & Best, 1997, emphasis added).

Thus in this system individual words do not act as effective units of selection. Moreover, the words alone are not meaningful, it is the combinations of words, found together across texts, that signify a meaningful unit of selection.

"The term-subspace is composed of a number of terms that when found together in a document represent the occurrence of a particular 'cognitive motif' . . . our matrix decomposition can be considered to screen various posts for the degree to which they 'bind' to a particular cluster of rare co-occurring words." (Pocklington & Best, 1997).

What evidence is there for this high-probability relationship between our co-occurring word sets and some quality of meaning? It is this very relationship that drives the modern field of text analysis, the fruits of which include web search engines, online news databases, and the like. There exists considerable evidence of this strong relationship between co-occurring sets of words and semantic elements. Indeed, the entire text analysis research programme, going back many years, is predicated on this relationship. (See for instance Salton & Mcgill, 1983; Mosteller & Wallace, 1984; Frakes & Baeza-Yates, 1992).

Gatherer & McEwan proceed to question how these replicators, however misunderstood, might have evolutionary significance. It is certainly true that not all replicating patterns necessarily evolve and adapt. As pointed out above, we found that single words in our system do not. (We do not wish to imply that natural selection is not relevant to word meaning or usage changes in general; but, it does not appear to be a strong force at the scale we examine in our paper.) In our paper we go on to demonstrate that certain term-subspaces have a significant trait/fitness covariance. That the relative presence of a particular co-occurring set of words covaries strongly with the text's replication success is a critical demonstration of evolutionary significance. We now have evidence that the same term-subspace has a similar covariance with fitness across multiple newsgroups dealing with different issues. Thus not only do these replicators have measurable effects on fitness, the effects are neither wholly contingent on the environment nor on the presence of other replicators (Best, 1998b).

3. Relevance to Languages Radically Different from English

Gatherer & McEwan (1998) claim that: "it is doubtful if their LSI analysis could apply to languages of radically differing grammatical structure".

In our paper we study discourse over UseNet News (NetNews) as a sample system in which we elaborate an empirically based model of cultural transmission. We have not directly studied how these methods may be extended beyond this system. We consider this criticism to be akin to the complaint, "Hey Mendel, get out of that garden. You will never learn anything about life in general there; animals don't even have seeds!"

We recognize that certain characteristics of English have important effects on our method. Durham (per. com.) has pointed out that due to the regular suffixing of nouns in English and the irregular conjugation forms of verbs, our technique will be biased towards cultural units that refer to objects and not to processes. This is a methodological issue that we can cope with through the use of more elaborate linguistic preprocessing. We note that the text analysis community has recently placed considerable effort into the study of multilingual methods. For instance, at the Fifth Text REtrieval Conference (TREC-5) there was a Spanish and Chinese language track (Harman & Voorhees, 1997). We look forward to more research in these areas.

We recognize this linguistic issue as an interesting problem, yet it is not relevant as a criticism of the results we have so far gathered. We wish to be clear that we see NetNews as a *model system* in which to explore issues of conceptual evolution and our technique is particularly useful in *this domain*. The principle of detecting reliably and repeatedly replicating patterns is generalizable to other systems, but the particular methodology we use is tailored not just to the English language, but to English discourse within NetNews. This strict constraint is an advantage, it provides a stable class of data sources that we can analyse in great detail, rather than an amorphous realm of culture in general in which other investigators may flounder. How exactly we would have to modify our system to support analysis of other sources of data is an on-going research concern of ours. The approach has been shown to be unsuccessful in the detection of literary motifs in native American and Germanic folklore. In its present incarnation it cannot differentiate between a corpus of Grimms fairy tales and a selection of Amerindian solar creation myths (Pocklington & Durham, 1998). Our implementation of the LSI method is perhaps limited to systems with large amounts of near verbatim copying (as occurs frequently in in-reply-to-threads on NetNews) and corpus sizes of thousands of texts.

4. Contrary and Alternate Usage's of Individual Text Elements

Gatherer & McEwan claim that our technique can not detect contrary and alternate usages of words. In one sense this statement is simply incorrect. The LSI technique can differentiate between alternative uses of a given word (homonyms, or the same word with several different meanings). This is one of the important strengths of the LSI technique and it is important to understand how it impinges on our method. The same *term* may be found to be an important component of more than one *term-subspace*. Thus when the term "suit" is found to occur with "dress", "ball", "dance" and "formal" it is found in one term-subspace. When we find "suit" along with "ace", "diamond", "bet",

"flush" and "bid" we have encountered a different "suit" and a different term-subspace. All our subsequent analysis is based on the re-projection of the posts into the term-subspace space. Thus the multiple meanings of individual terms is taken into account by our method.

We do recognize that this process is by no means perfect. Yet we do not need it to be perfect for the purposes of our model. For all of the term-subspaces reported in our paper we verified by inspection of the texts that the system had indeed discovered term-subspaces which were of similar meaning across the texts. Our inspection discovered an error rate less than 10%.

In another sense Gatherer & McEwan's criticism is interesting, and opens up potential future work. We have indeed argued that posts containing the terms "jesus", "save" and "messiah" belong to the same conceptual unit regardless of their "if's", "and's" and "not's". Thus the replicating pattern may be a discussion as to whether or not Jesus is a messiah and whether or not he saves anyone. In our finding of the high trait-fitness correlation of the "james", "smith", "nazi" term-subspace, we recognized that there were posts claiming that James Smith was a Nazi, along with posts claiming that no one should call anyone a Nazi, not even James Smith. What we found for all cases was that the inclusion of the terms "james", "smith", and "nazi" into the discourse caused a huge surge in postings in response. And we have since found that related term-subspaces have a high fitness in other environments as well (Best, 1998a, b).

That we are able to find evolutionary significance even with our simplifications which ignore positive and negative senses is one of our most valuable findings. We have shown that the sets of co-occurring terms described by term-subspaces actually do have sufficient conceptual coherency to demonstrate evolutionary significance such as trait/fitness covariance. But, there may indeed be some circumstances where the positive and negative version of a statement are really different in ways that are relevant to our model. In future work we would like to refine our method in order to take into account more linguistic structure.

Gatherer & McEwan claim that our method is of no value because it attempts to "posit meaning to individual words independently of their context in [Wittgenstein] language games." We have already shown that we do not treat individual words as significant out of their context. Further, our work is actually consistent with an informed reading of Wittgenstein. If the authors of our posts are engaged in a language game, as Wittgenstein would claim, then our technique of identifying examples of word *usage* should indicate meaning in a way quite satisfactory to Wittgenstein. Wittgenstein writes that "giving examples of usages is not a second-best method of giving the meaning of a word" it is the only way to talk about meaning (Wittgenstein, 1979). "Here giving examples is not an *indirect* means of explaining—in default of a better . . . The point is that *this* is how we play the game. (I mean the language-game with the word 'game".)" (Wittgenstein, 1958). In Wittgenstein's terms, we use a statistical method to group *meaning* insofar as we group together salient "examples of usages". Thus, Gatherer & McEwan's attempt to place us in conflict with Wittgenstein seems inconsistent with a careful reading of our work and our understanding of Wittgenstein's writings (see Hallett, 1967; Canfield, 1981; Rundle, 1990).

5. Fecundity of Threads

Gatherer & McEwan criticize our use of in-reply-to threads as a lineage mostly by noting that people often post irrelevant texts to a thread. We agree that posts are not always on topic within a thread. But, if some small percentage of the texts are off topic our results should be robust in the presence of such noise. In other analysis we have made use of clustering techniques to group together texts into quasi-species (Best, 1997, 1998a). In this case, the conceptual genealogy is measured directly without making use of the threading system. (In fact, the reason we abandon this technique for our paper is that referees generally seem to prefer the conceptual simplicity of the in-reply-to thread system.) In the cases of quasi-species we verified the clusters by hand to establish that texts brought together were indeed on a single

topic. Here we were seeing about a 10% error rate; thus we group together texts where about 1 in 10 are not on topic. Our subsequent analysis is certainly robust to this sort of error rate.

What is clear in either case, the system provided threading or our own clusters, is that as these texts unfold in time they pass on a considerable set of traits in the form of repeating word co-occurrences (and thus high-probability semantic relatedness). This occurs both due to the system's automatic inclusion of the previous message's text as well as through the action of the human authors. This is not a statement of theory but an empirically demonstrated and easy to verify fact. The result is that a subsequent message is highly likely to share considerable traits with its parent message relative to the population of messages as a whole. Thus, we have a lineage with heredity (Dawkins, 1982).

6. Other Types of Cultural Units

Gatherer & McEwan cite the cultural transmission work of Guglielmino *et al*. (1995) as examples of well defined units of transmission. We suspect, though, that they are unfamiliar with some of the problems inherent in this type of work. We must point out that the generic lumping of culture into "customs, rituals and practices" (Gatherer & McEwan, 1998) is precisely the problematic approach to cultural units that we are attempting to redress with our analysis and description of particular units of transmission. Guglielmino *et al*. (1995) have provided us with a method with which we might estimate the predominant mode of transmission of a variety of cultural characters. However, they create their cultural characters *ad hoc*, based on the names of variables they found in the ethnographic atlas (Murdock, 1967). Pocklington (1996) has shown that the variables in their category "division of labor" are an amalgam of several distinct cultural characteristics that does not represent a coherently transmitted unit. The variables amalgamated into this category included the division of labor by sex in agriculture, leatherworking, animal husbandry, boat building, house building, fishing, pottery and

metal working. The variables in this cluster are more appropriately divided into three distinct realms of culture that have different transmission modes (Pocklington, 1998). In particular, in the sample they used, in all societies with metal working, it was done exclusively by males. Thus the trait "division of labor by sex: metal working is really showing information regarding the presence or absence of metal working. This data is closely tied to the degree of social hierarchy in the society, and not directly to gender issues. Lumping variables together as transmission units because they were given similar names by others is a poor strategy for determining evolutionarily relevant units. Other analyses of African cultural diffusion have found that it is frequently a group of technologies, social practices, cultivars and values that diffuse together as a coherent unit of transmission [such as a type of hoe, beliefs about appropriate planting times, a type of yam and a yam ceremony (Zwernmann, 1983)].

Our method was in part a reaction to the oversimplified use of categories of culture used in cultural transmission studies. Indeed, the problem of deciding upon the appropriate unit of analysis in cultural transmission dates to the dawn of the study of cultural diffusion with Bastian (1881) and Ratzel (1882) and the issue has not yet been solved.

7. The Alternative

We find their suggestion of an alternative perspective unconvincing. The brief sketch they present of their method suggests that they believe that "meme theory" is another way of stating sociological functionalism. To refer to NetNews discourse as serving: "the function of providing political expression in repressive climates or simply informing individuals that they are not alone, like-minded fellows exist. Herein lies its meaning, its biological function to the extended phenotype" (Gatherer & McEwan, 1998) is in our opinion misguided.

We do not believe that it is sensible to refer to the function of a type of discourse exclusively with respect to the Darwinian fitness of the practitioners. This would be excessively simple sociobiology. We are interested in the adaptations that occur *at the level of the replicator*.

Only these types of function can be said to have come about through natural selection.

Williams (1966) outlined a conceptual revolution in evolutionary biology when he stressed the limitations on the concept of adaptation and function that was at that time plaguing evolutionary biology. He argued: "Benefits to groups often arise as incidental statistical consequences of individual activities" (Williams, 1966). We see a clear distinction between the kind of function we are interested in exploring (e.g. somehow the idea represented by the words "james", "smith" and "nazi" in our NetNews sample may be adaptive in that it promotes self-replication) and an analysis of the social function (if any) served by NetNews. If there is a function to NetNews as a whole, it is not likely to have come about through adaptation due to natural selection.

The attribution of "high level" function to all of social behavior was a trend in biology and sociology that ran out of steam in the 1960s. This type of panglossian sociological adaptationism culminated in statements like the following passages by Norbeck (1961): "group participation in any kind of activity presumably intensifies social cohesion" and "crime may be looked upon as supporting society by providing a livelihood for law enforcement officers and the numerous specialist required to feed, house, clothe and attempt to rehabilitate criminals." The days of such naive group selectionist functional explanations are over. We cannot assume that everything that exists does so because it fulfills some unknown telos (Williams, 1966). If we are interested in adaptations, then we must identify effective replicators and at this level examine for the evidence of design for survival (Dawkins, 1982).

Cultural evolution, if applied to the large scale social functions referred to by Gatherer & McEwan, is not a likely outgrowth of contemporary evolutionary theory; it is instead a return to earlier thinking in sociology (Spencer, 1874).

8. Evolutionary Theory and the Pleasures of Reductionism

Gatherer & McEwan criticize our results because we attempt to "reduce cultural evolution

to the dynamics of replicating elements." We recognize this attitude towards reductionism as a source of some controversy, and there is currently a vogue of "wholister than thou" (apologies to Dawkins) pundits who admonish all who reify, quantify and otherwise split big things down to bits of essence. To the claim that we are reductionist we plead: guilty. We also admit to being "adaptionist" and "selectionist" (if not pan-adaptionists or pan-selectionists). We argue that the development of a useful scientific theory of cultural evolution will necessarily use methodological reductionist techniques in order to reduce the complex dynamics of the cultural evolutionary process into operational and tractable parts. Gatherer & McEwan may wish to claim they share our interest in evolutionary theory. However, the overall thrust of their letter relies on a set of philosophical concerns that edges towards the mystic. In this way, they seem to abandon a scientific theory of the evolutionary process, which by its nature is operational and reductionistic. We strongly support the project of many evolutionary biologists to reduce organic evolution to the dynamics of replicating elements. We believe that such a tactic is working quite well. If evolutionary theory can act as the glue which binds together such disparate areas of study as the origin of life (Orgel, 1973), the major transitions in organic history (Maynard-Smith & Szathmary, 1995), animal instincts (Tinbergen, 1951), and software development (Michalewicz, 1994)—why not cultural replicators?

When Gatherer & McEwan describe our work as a "biological metaphor", we see a manifestation of their philosophical orientation. The sort of cultural evolution we are studying is not, we argue, working primarily within a *metaphor* of biology (although we do admit to this in some cases, such as the likening of the transcription of protein to the decoding of linguistic meaning). Our work, we argue, is an example *quite precisely* of evolution. Organic biology is yet another example. As we indicated in our opening quote from Fisher (1912), evolution is not a process limited to organic systems; it is a simple if-then proposition. If you meet certain necessary and sufficient conditions then you will have evolution. In our paper we enumerate what we believe to be a sensible set of conditions and then attempt to examine each of them within our model. Our results indicate that evolution by natural selection is occurring in the system.

Thus we do not work within metaphor; but we happily work within a reductionistic framework. While we do not claim this is the only valuable means with which to study evolution, and in particular culture evolution, we do certainly believe it is one valuable mode of inquiry. The results we are beginning to accumulate should stand trial on these terms.

9. Conclusion

We conclude that Gatherer & McEwan's primary criticism is due to their misunderstanding of our main result (the term-subspace as replicator, not the word as replicator), and their subsidiary criticisms (e.g. the English language limitation) are minor points that do not impinge upon the general validity of our modest proposal. Nowhere do they lay out a clear description of an alternative, nor do they go so far as to question our quantitative results in any specific way (although they do claim that our result "is meaningless", "unsuprising" and "of doubtful evolutionary relevance").

We would like to call close attention to what we consider to be the concise and modest claims that we did make in our paper. Our method provides the possibility for investigations of a model system in the study of cultural evolution (NetNews discourse). We claim to find statistically significant co-occurrences of words which re-occur across texts over time. We find that certain of these word sets are of evolutionary significance since they vary over time and their usage strongly co-varies with the replication success of the texts in which they are found. We claim that attention to the empirical details of cultural transmission is an essential preliminary step if cultural transmission theory is to progress beyond the realm of the purely hypothetical. We do *not* claim to have built a general-purpose system that will work without modification outside of NetNews discourse nor in languages completely dissimilar to English, nor do we claim to "define a meme", understand the "atomic nature of thought", "explain religion", or "find meaning" (in the generic sense).

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