GRAMMATICALISATION AND EVOLUTION

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Grammaticalisation is relevant for language evolution in two ways. First, it is possible to model grammaticalisation processes by evolutionary simulations (iterated learning). This paper provides two such models of a central step in the grammaticalisation process: the recruitment of lexical and functional words for a new functional role. These models help in better understanding the processes involved. Second, it is possible to reason backwards to earlier stages of human language. The paper argues that all that is necessary for the genesis of natural languages is the conventionality of the form-meaning association and the possibility of introducing new lexical words. Once there is a communication system of this kind, all the additional complexities of human languages follow.

1. Grammaticalisation

Functional items in natural languages comprise prepositions, particles, auxiliaries, determiners, pronouns of different kinds and inflectional morphology. To the extent that their etymology is clear, they are -often phonologically reduced- versions of lexical nouns and verbs, one of the reasons why it is generally believed that all functional items come from lexical words. It is also hard to see in what way one could introduce a word for the meanings of functional items, since it is impossible to establish joint attention to abstract concepts like negation, past, possibility or uniqueness without linguistic means for expressing these concepts. The process by which lexical words change into functional items is called grammaticalisation and examples of it have been extensively studied by historical linguists. The following general characteristics (Pagliuca, 1994), (Traugott, 1993)) are standardly assumed:

1. Bleaching of the meaning of the word towards a weaker, vaguer and more pragmatic meaning.
2. Rise in frequency and obligatoriness
3. Phonological and syntactic reduction

Let me try to illustrate these properties by a simple example. The article $a(n)$ transparently derives from the cardinal one. One is more optional in the sense that it never appears just for syntactic reasons as $a(n)$ does. In consequence, the frequency of $a(n)$ is also much increased with respect to that of one. The meaning

of one can be characterised as saying that the intersection of the denotations of the noun and the predicate has precisely one member. The meaning of $a(n)$ is often described as: the referent of the complex phrase is unfamiliar to the hearer. This is weaker, vaguer and more pragmatic. Finally, it is clear that there is a phonetic reduction both in the loss of a vowel feature and in the optionality of the final nasal.

The targets of grammaticalisation are not arbitrary. The typology of human languages includes aspect and tense marking, modality, particles, case systems, pronouns and prepositions and while there may be vast differences in the inventories of different languages both in the concepts for which a functional item is present or in the category in which it is realised, there are very substantial overlaps in the functions that get marked. These overlaps are brought out by the semantic map methodology (Croft, 2003), (Haspelmath, 2003), (Auwera & Vladimir A. Plungian, 1998), (Malchukov, 2004). The concepts expressed are central and the conclusion that the functional items are needed because otherwise the expressivity of our languages would be insufficient for the purposes that we pursue with our linguistic communication is unavoidable. I will here not model phonetic reduction.

There can be no proof that the models presented here are correct, but only that something analogous to grammaticalisation happens under the described conditions. On the other hand, an informal concept that cannot be underpinned by an evolutionary reconstruction is flawed. There is at the same time ample space for other models of grammaticalisation, both within the same framework ("Gricean evolution") or in other concepts of evolution, but I am not aware of any other work.

2. Basic Concepts

Meanings are linked to forms by a convention. A corpus is —in the contexyt of this paper— a collection of such conventions that has one record for every time a certain meaning is used with a certain form. A corpus can be represented by an assignment of probabilities to form-meaning pairs. $p(Form, Meaning)$ is the number of times that $Form$ was used meaning $Meaning$ divided by the total number of times anything was used with any meaning. A corpus can then be represented by a function $f : Forms \times Meanings \rightarrow [0, 1]$ such that $\Sigma_{Form \in Forms, Meaning \in Meanings} f(Form, Meaning) = 1$

The corpus is taken to determine both how a speaker would express a meaning and how a hearer would interpret a form. The speaker selects a form for a meaning according to the probability that that form is used for that meaning. I.e. if the speaker wants to express M the probability that she will select F to express it is $\frac{p(F,M)}{\Sigma_{G \in Forms} p(G,M)}$.

Similarly the hearer will select the meaning M for the form F with the probability $\frac{p(F,M)}{\Sigma_{N \in Meanings} p(F,N)}$.

A communication act starts with the speaker selecting a meaning for communication. The speaker selects this meaning as speakers do, i.e. with a probability that can also be determined from the corpus as the probability $\Sigma_{F \in Forms} p(F, Meaning)$. This reflects the natural frequency of the meaning and reflects the propensity of speakers to select the meaning $Meaning$. We identify the natural frequency with its value in the first corpus. Natural frequency could in principle be determined by looking at a set of corpora for different languages, under the assumption that the natural frequency of meaning is an invariant over languages.

A communication act is successful iff the hearer will correctly interpret the form as having the meaning the speaker intended to communicate with her expression. The corpus representing the next generation will consist of only the successful communications. This reproduces $p(F, M)$ as $natural_frequency(M) * \frac{p(F,M)}{\Sigma_{G \in Forms} p(G,M)} * \frac{p(F,M)}{\Sigma_{N \in Meanings} p(F,N)}$. Normalisation to 1 gives the next corpus.

Evolution is modeled by iterating this process thus following the paradigm of iterated learning (Hurford, 2002).

This can be called Gricean evolution (because it employs the Gricean criterion of success in communication from (Grice, 1957)) or bidirectional evolution (because it is related to optimality theoretic bidirectionality (Blutner & Zeevat, 1994)). The next two notions are corrections on the notion of success. The first is $Importance$. A semantic feature is **important** if not recognising it when it is intended is worse than wrongly assuming it is there when it is not. (Though strictly speaking neither is successful.) Let M and M' be such that M is M' without the important semantic feature. In that case if M is chosen when it should have been M' is just failure whereas choosing M' when it should have been M is still somewhat OK, perhaps half of full success.

A good example of an important feature is the speech act of correction. Corrections need to be processed differently from straight assertions because the corrected material needs to be removed (or be made harmless in other ways), so it is important to recognise it. Wrongly assuming that one is dealing with a correction is not problematic: there is just nothing to remove. But not recognising a correction would lead to inconsistent information.

Ambiguities are the causes of lack of communicative success. But ambiguities come in flavours. Some ambiguities are protected by pairs of presuppositions that —in case the presuppositions are part of the given information as they should be— guarantee that the hearer gets the right reading. We can call this an **protected ambiguity** and correct the success rates as follows. Let F be an isolated ambiguity between M and M'. Then the chance that the hearer gets it right for either M or M' is $\frac{p(F,M)+p(F,M')}{\Sigma_{N \in Meaning} p(F,N)}$ (or close to that).

The final notion to be introduced is weak entailment. This is a probabilistic logical notion that is defined by: M weakly entails M' iff $p(M'|M) >$

$p(\neg M'|M)$. It is just a property of the initial probability assignment: $\Sigma_{F \in Forms} p(F, M \wedge M') > \Sigma_{F \in Forms} p(F, M \wedge \neg M')$. Weak entailment can be due to many different relations, such as generalised conversational implicature, default inferences (ravens are black), causal reasoning (glass breaks if it falls on hard floors) and others. The negation must sometimes be interpreted as the absence of the feature, e.g. the negation of correction is a proper non-correcting assertion.

3. The Weakening Model

Suppose:
F means M and M weakly entails M'
M is less frequent than $\neg M$
M' is less frequent than $\neg M'$
M' is important.

Then *ceteris paribus* and eventually, F will start meaning M'. If moreover $\neg M \wedge M'$ is more frequent than M it will take over F entirely (**usurpation**), otherwise F will be ambiguous between M' and M (**spread**).

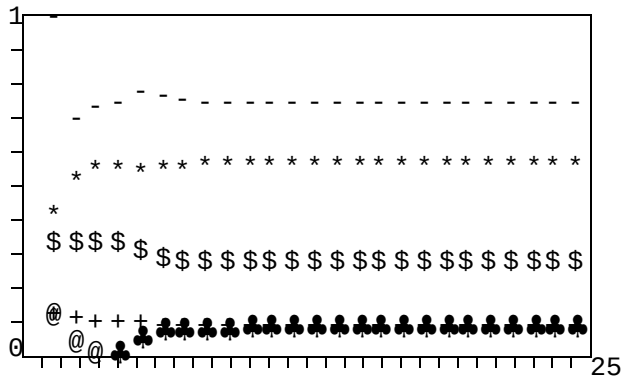
Ceteris paribus forbids the presence of other elements that could express M', *eventually* indicates that it happens after a number of generations when the model reaches stability.

The main reason why the change occurs is because the meaning $\neg M \wedge M'$ is dominated by $\neg M \wedge \neg M'$ as a meaning for zero expression. It is bad to interpret something as its non-dominant meaning and it becomes worse. As it goes on, it negatively affects the choice of zero-marking as a means of expression of $\neg M \wedge M'$ in favour of its competitor F. Since F is more successful (M' is important) F as a means of expression of $\neg M \wedge M'$ grows and will start meaning it more and more often. The growth is limited by the natural frequency of $\neg M \wedge M'$ and this determines whether usurpation will happen or not.

The following is a picture produced by a simulation. The original corpus frequencies are:
zero, $\neg M \wedge \neg M'$, 200
zero, $\neg M \wedge M'$, 100
zero, $M \wedge \neg M'$, 1
zero, $M \wedge M'$, 1
F, $\neg M \wedge \neg M'$,1
F, $\neg M \wedge M'$, 1
F, $M \wedge \neg M'$,20
F, $M \wedge M'$, 50

M''s importance makes it worse not to recognise M' than to overrecognise it. This favours means of expression which are more biased to recognising M'. The value is here set to 0.5. E.g. if one tries to express $X \wedge \neg M'$ and the hearer

recognises $X \wedge M'$, it is still half right.



Spreading grammaticalisation of F to start meaning M without M (♣♣♣♣♣). M without M starts out by being zero-expressed (). The zero-expression is eventually monopolised by the absence of M and M' (). The uses of F for M and M' ($$$$$) and for M without M' (+++++) are reduced but preserved.

The model explains the rise of frequence of the grammaticalised item, both on spread and on usurpation. Weak entailment takes care of the weaker, vaguer and more pragmatic meaning, with spread responsible for the extra vagueness.

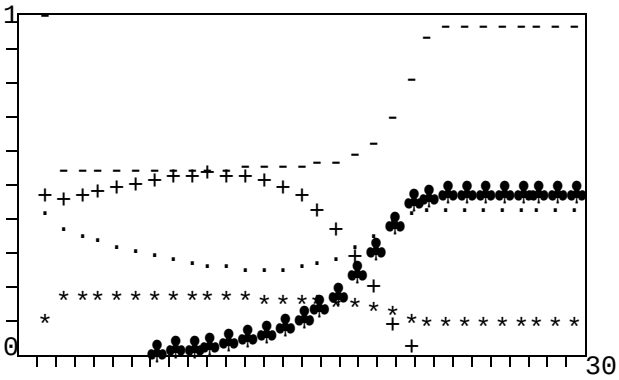
Spread in the recruitment of functional items is responsible for the emergence of the lexicographical nightmares like prepositions, cases, certain aspect classes and certain particles. Usurpation of functional items in its turn leaves behind an expressive gap which will be filled in by new recruitments.

The major conflict with what is known about grammaticalisation processes is the assumption that there is nothing available for expressing the important new meaning. If one adds a good expressive possibility to the model, nothing will happen. But this situation seems to occur with a reasonable frequency (Pagliuca, 1994). It is probably necessary to see the alternative expressive possibilities as bad, at least for weakening.

Metaphor is different because it does not involve weak entailment of the new meaning but especially because it gives very good expression alternatives in the form of a protected ambiguity. Metaphorical expression works only in a context where it is clear that the literal interpretation cannot apply. In this situation the intended interpretation is the most strongly suggested alternative. The notion of suggestion based on similarity and analogy cannot be modelled inside a statistical model. Both the old meaning and the new meaning are fully protected from each

other in this case. If the context allows the old meaning, that meaning will be chosen, if the context doewas not allow it, the new meaning will be chosen.

In the metaphor model, there is an ambiguous way of expressing the target meaning, a form shared by the target meaning and a distractor meaning. Initially, the carrier of the metaphor has its old meaning, with the metaphorical meaning being a rare event. Since these two meanings are protected from each other, the metaphorical use of the carrier is more successful than the old ambiguous expression for the target meaning. Protection can be modelled by twisting the success rates: the source and target meanings of the carriers are just added.



Grammaticalisation by metaphor. Initially the meaning M shares a form G with a distractor meaning D (+++++ and .....) and M is also a rare metaphoric interpretation of form F meaning M (♣♣♣♣♣ and *****). The success of the metaphoric expression of M leads to its becoming the standard way of expressing M and the monopolisation of G by the distractor meaning D.

4. Language Evolution

The grammaticalisation events modelled in the last two sections happen under circumstances that are not rare at all. It seems safe to say that a human language without functional inventory is inherently unstable: there are lots of important distinctions (in the sense of section 2) that go unexpressed and will attract weakening and metaphorical grammaticalisation. Adding phonological decay and syntactic evolution, such a language will evolve into something like the human languages we know: with verbal and nominal morphology, discourse particles, conjunctions, prepositions and clitics. Also with grammatical meanings like modality, tense, evidentiality, mood, case and thematic roles. The study of word order freezing

((Jakobson, 1984) (Lee, 2001) and (Zeevat, to appear) indicates that the conditions on word order arise naturally under functional pressure and can explain the arisal of permanently frozen constructions as one finds in e.g. English or Chinese from the weaker word order tendencies that one finds in Sanskrit, Korean or Russian. While many of the processes are only partially understood and formal analyses are almost completely lacking, it seems that the application of the iterated learning method for modeling these processes has serious potential. I hope to have made a case for that in the preceding sections.

One can also reason backwards to the minimal conditions on languages for grammaticalisation to start. If it is possible to adopt new words with lexical meanings and if the words can be combined into complex messages, one obtains the inherently unstable language in which grammaticalisation will start. So those are the only two things that biology needs to account for.

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