Radical Interpretation Described using Terms from Biological Evolution.

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Abstract

A common method of improving how well understood a theory is, is by comparing it to another theory which has been better developed. Radical interpretation is a theory which attempts to explain how communication has meaning. Radical interpretation is treated as another time dependent theory and compared to the time dependent theory of biological evolution. Several similarities and differences are uncovered. Biological evolution can be gradual or punctuated. Whether radical interpretation is gradual or punctuated depends on how the question is framed: on the coarse-grained time scale it proceeds gradually, but on the fine-grained time scale it proceeds by punctuated equilibria. Biological evolution proceeds by natural selection, the counterpart to this is the increase in both correspondence and coherence. Exaption, mutations, and spandrels have counterparts metaphor, speech errors, and puns respectively. Homologous and analogs have direct counterparts in specific words. The most important differences originate from the existence of a unit of inheritance (the traditional gene) occurring in biological evolution - there is no such unit in language.

Contents

1 Introduction

1.1 Motivation

Since Darwin propounded the theory of biological evolution in 1859 there have been attempts to compare and contrast it with other time dependent phenomenon. The relationship between biological evolution and cultural evolution Steward (1956) [51] is one of the best know and studied examples of comparing a time dependent changes with biological evolution, moreover it illustrates some of the pitfalls and advantages of doing so. The advantages are that several disconnected societies seem to go through similar stages, allowing the possibility of extracting the factors which cause this. The pitfalls are mainly a result of how to fit interaction between societies into an evolutionary model. Societies gather artifacts and techniques from one another and thus do not always obtain these in the same order. The spread of artifacts and techniques can occur either through *cultural diffusion*, or alternatively the people that posses them can move, this is know as *demic diffusion* Renfew (1994) [45] p.108. An example of demic diffusion is the spread of farming through Europe, Menozzi et al (1978)[38]. A second frequently made comparison is given by the relationship between biological evolution and economics, Alchian (1950) [1] p.200:

> The economic counterparts of genetic heredity, mutations, and natural selection are imitation, innovation, and positive profits.

Ideas from evolution have also been applied to the change in conceptual systems, Hull (1992) [23]. Of course, most structures change with time and can be referred to as "evolving" and of as being a "process". Thus there is the danger of making straightforward but vacuous remarks when comparing them. What these examples have in common is an evolving tree structure (or cladistics), which can be compared. Hierarchical tree structure and its application to syntax have been discussed in Roberts (1998) [46]. In this paper biological evolution is compared to radical interpretation, there are two reasons for doing this. The *first* is that it allows it to be shown that there are more differences than similarities between the two theories. The *second* is that it allows some aspects of radical interpretation to be delineated in the more precise terminology of biological evolution.

1.2 Sectional Contents

In section 2 terms from biological evolution are introduced. The terms which turn out to be the most useful are those of Gould and Eldridge (1994) [16] - these terms are not thought by all biologists to be appropriate for describing biological evolution. Radical interpretation is concerned with how a language community can assign truth values to the utterances of other members of the same community. Collections of papers on radical interpretation include Martinich (1996) [37] and Horwich (1994) [22]; textbooks include Ramberg (1989) [43] and Evine (1991) [13]; and online articles Kirk (1998) [27] and Malpas (1996) [34]. According to the notion of *radical interpretation* assigning truth is sufficient to assign meaning to these utterances. The motivation for this assertion comes from analogy with radical translation and this in turn is motivated by analogy with truth in formal languages. Truth in formal languages is most often described by Tarski's truth theory. Meaning in formal languages might be constructed by the methods of Angluin (1980) [2]. Here truth in natural and formal languages is discussed in section 3. In section 4 the supposed skill which allows an anthropologist to understand the the language of a previously isolated community and whether this is a particular example of *radical translation* is discussed. Traditionally the assignment of truth is what is required for radical interpretation, here this is generalized to allow for the possibility that truth is an inadequate notion to describe the quality that is assigned to linguistic structure; thus truth is replaced by the more guarded terminology of *extralinguistic information.* The extralinguistic information which drives radical interpretation is usually taken to be supplied by (the misleadingly termed) *principle of charity*; in section 5 this is replaced by the *principle of cooperation dominance.* In section 6 arguments are given showing when terms in biological evolution have counterparts in radical interpretation. Radical interpretation is further developed in Roberts (1998) [47].

2 Biological Evolution

2.1 Traditional Evolution

Biologists account for the origin of existing species from ancestors unlike current species by invoking the theory of *biological evolution*, see for example Dawkins (1976) [11], Pinker and Bloom (1990) [40], Gould and Eldridge (1993) [16]. The evolution of new species is generated by natural selection.

Natural selection is a process resulting in the survival of those individuals from a population of plants or animals that were best adapted to the prevailing environmental conditions; the survivors tend to produce more offspring than those less well adapted, resulting in the composition of the population being changed. *Speciation* is the evolutionary development of a new biological species. Kondrashov (1992) [29] splits speciation into two kinds: *allopatric* speciation occurs when species arise as the by-products of evolution in geographically isolated populations, otherwise speciation is *sympatric*. *Convergent evolution* is the evolutionary development of a superficial resemblance between unrelated species that occupy a similar environment, an example is the evolution of wings in both birds and bats. *Homologous* means having the same evolutionary origin but different functions, an example is that the wing of a bat and a paddle of a whale are homologous. *Analogous* means having the same function but different evolutionary origin, an example is that the paddle of a whale and the fin of a fish are analogous. *Cladistics* Sneath and Sokal (1973) [50] p.29 means the study of the pathways of evolution; for example how many branches an evolutionary tree has, which branch comes off from which other and in what sequence. If the branches can fuse then evolution is referred to as *reticulate*, Sneath and Sokal (1973) [50] p.352. Reticulate evolution is rare in animals but can occur in plants where hybridization between distinct species and even distinct genera is possible. To quote Maynard-Smith (1987) [36], the *Baldwin effect* is

> If individuals vary genetically in their capacity to learn, or to adapt developmentally, then those most able to adapt will leave most descendants, and the genes responsible will increase in frequency.

2.2 Punctuated Equilibrium

Traditionally natural selection is taken to be both gradulistic and adaptionistic. Gradualism means that the changes which occur are not abrupt and happen in small stages. Adaptionistic means that changes happen in a direct and explicit manner. Specifically an adaption is an inherited or acquired modification to a species that makes it better suited to survive and reproduce in a particular environment. These days both of these properties are in contention. Instead of evolution proceeding by gradualism it can proceed by punctuated equilibrium as discussed by Gould and Eldridge (1993)

[16] and by Pinker and Bloom (1990) [40] p.711. Pinker and Bloom describe *punctuated equilibrium* as follows

> According to the theory of punctuated equilibrium most evolutionary change does not occur continuously within a lineage, but is confines to bursts of change that are relatively brief on the geological time scale, generally corresponding to speciation events, followed by periods of *statis*.

Instead of adaptionism there might be indirect and implicit natural selection through exaption and spandrelization. *Exaption* means new uses for parts originally adapted for some other function. *Spandelization* means uses for parts which originally occurred as a by-product necessitated by other structure: spandrels come in at least two types. *Ephenomenal spandrels* in which the structure is simply a by-product, examples are: the redness of blood, the hollow at the back of the knee. Spandrels which have since been changed by direct natural selection are *modified spandrels*, examples of these are chins and hexagonal honeycombes. Bowring et al (1993) [6] have calibrated the rate of early Cambrian evolution and found that the Tommatian and Atdababian stages lasted less than ten million years. During these stages a large variety of new life forms appeared, therefore biological evolution must have scope to accommodate rapid change - traditional gradualism cannot do this.

3 Truth in Formal and Natural Languages

3.1 Truth in Formal Languages

At first sight it would seem that if the truth or otherwise of a sentence is known then by necessity its meaning must be known; furthermore the meaning of a sentence can be known but its truth be undetermined. Radical interpretation reverses this picture and takes truth as the primary notion. The truth value of a sentence is taken to be assigned by appealing to extralinguistic information, allowing the meaning of a sentence to follow in a manner which allows the best fit to these truth values. How the assigning of truth values is accomplished is discussed in the next two sections, this section is limited to conceptions of truth. Theories of truth are discussed in Kirkham (1995) [28].

Tarski (1967) [52] p.63 and Evine (1991) [13] p.82 point out that Aristotle had a notion of truth, expressed in his Metaphysics

> To say of what is that it is not, or what is not that it is, is false; while to say of what is that it is, or what is not that it is not, is true.

Tarski's approach is to take a formal object-language which has sentences that can be true or false, and then compare these these sentences to sentences in a meta-language. In order to consider what would be involved in a definition of truth, consider what would be involved in any definition. There are two *formal conditions of adequacy*: i) the definition must take the form of a one place predicate, ii) the DEFINCIENS must not contain the DEFIENDUM or words constructed from the DEFIENDUM; and one *material condition of adequacy*: iii) the definition must entail all and only instances of the word being defined. The condition of material adequacy for a definition of truth can be expressed formally using *criteria* W (also called convention T, form T, schema T):

$$s \varepsilon T \qquad iff \qquad p \qquad\qquad\qquad (W) \tag{1}$$

where s is sentence in the object-language, and p is a sentence in the meta-language. A sentence for which (W) holds is called a W-*sentence* (also a T-sentence, Evine (1991) [13] p.80).

Consider a very simple formal object language with two sentences:
i)The cat sat on the mat.
ii)The earth is round.
The sentence in the object language are said to be true iff (if and only if) they are true in a meta-language. The same approach works for languages which have any finite number of sentences.

Now consider a formal object language which consists of a finite number of sentences and the connectives $\{not, and, or, if \ldots then\}$ of the predicate calculus. With these one can construct sentences of infinite length and also an infinite number of sentences. One says a sentence is true iff it is a combination of true sentences and connectives which are well formed formulas (wffs) and are true according to the rules of the predicate calculus.

Next one needs a conception of truth which will work for quantified predicate logic. Quantifiers are $\forall$ (for all) and $\exists$ (there exists), and these range over the variables in a sentence. A variable is free in a wff if it is not bound by a quantifier. A closed sentence has no free variables, every word is specified. A well formed sentence is open if it has an unbound variable. An example is 'x is the father of John', it is open because x is not specified. Truth cannot be assigned directly to open sentences, one has to introduce the notion of satisfaction. First consider open sentences with one free variable, then the sentence is *satisfied* if there is a particular choice of free variable for which it is true. Sentences can be further complicated by having more than one unbound variable, there can be an infinite number. In this case an open sentence is satisfied if there is a *sequence* (ordered set) for which it is true. A *true sentence* in the object language is a sentence which is satisfied by every sequence.

3.2 Truth in Natural Languages

Truth in natural languages is more contentious. Tarski (1969) [52] p.65 thinks that the formal language definition of truth cannot be extended to natural languages because of the antinomy of the liar. I agree with this, this is one of the reasons that I have for reformulating radical interpretation with extralinguistic information assigning a quantity Q to sentences. In the traditional view this quantity Q must be truth or falsehood, I can think of no compelling reason for this to be so. There is also the problem that sentences in natural languages often contain demonstratives. *Demonstrative* means denoting or belonging to a class of determiners used to point out the individual referent or referents intended, examples are: this, that, these, and those. Sentences which contain demonstratives in isolation are not indexed to a particular context, especially a specific place and time; because of this such sentences are sometimes referred to as *indexicals*. The problem arises as to how to assign a truth value to a single sentence which contains an indexical. Davidson's (1984) [10] p.131 approach is this requires a new theory of truth, which incorporates natural languages and can be used as a theory of interpretation, and thence meaning. The first problem that needs to be addressed is whether Tarski was correct in his contention that his definition of truth cannot be extended to natural languages. Davidson (1984) [10] p.133 suggests splitting the problem of truth in natural languages into two stages:

> In the first stage, truth will be characterized, not for the whole language, but for a carefully gerrymandered part of the language. This part, thought no doubt clumsy grammatically, will contain an infinity of sentences which exhaust the expressive part of the whole language. The second part will match each of the remaining sentences to one or (in the case of ambiguity) more than one of the sentences for which truth has been characterized. We may

think of the sentence to which the first stage of the theory applies as giving the logical form, or deep structure, of all sentences.

My view is that the first stage requires two incompatible criteria to be met simultaneously; and that the second stage is redundant - once the sentences have been matched they will have logical form and hence be part of the first stage.

An extreme view is radical pragmatism, the proponents of which hold that there is no such thing as literal meaning, the implications of this is that there is no such thing as a theory of truth even for a formal language. Another problem with assigning logical form to sentences is that in the empirical sciences results of experiments are analyzed statistically, resulting in statements being probabilistic: however for formal languages of the type considered by Tarski predicate logics etc. are used. For simple cases these two different types of statement are not compatible because of the different properties held by 'implies', see for example Calabrese (1987) [8]. This is another reason (in addition to the antinomy of the liar, as discussed above), for assigning a quantity Q to sentences, rather than restricting Q to be truth or falsehood.

4 Radical Translation and Interpretation

4.1 Radical Translation

Radical translation, Quine (1960) [41] Ch.2, is a hypothetical skill in which an "anthropologist" attempts to assemble a translation manual for an unknown language. Quine gives an example of how the translation manual could be compiled, it involves the anthropologist noting that a "native" utters the word GAVAGAI when a rabbit runs past. The anthropologist then sets up a hypothesis to test, he guesses that 'GAVAGAI' means 'there is a rabbit'; he then notes in future when 'GAVAGAI' means 'there is a rabbit' match up, in order to see if any qualification to the translation is necessary and to confirm that the translation has been successful. In this behaviourist manner a translation manual between the two languages evolves. A problem arises because concepts in one language might not have a direct counterpart in the other language; this is an aspect of the Sapir-Worf hypothesis, Kay and Kempton (1984) [26].

4.2 Radical Interpretation

Radical interpretation is a supposed skill similar to radical translation, but where there is only one language present. Meaning is assigned to sentences in the language when extralinguistic evidence suggests that it is appropriate to do so; the nature of the extralinguistic evidence is not made explicit; for example there is little variety in the emotional impact of facial expressions, Ekman et al (1983) [12], so that it is difficult to imagine the extralinguistic evidence originating there.

4.3 The Size of Structure Interpreted:Memes,Glossemes, and Conventions

Gesture and speech have been noted to be used in parallel in human communication, McNeil (1985), and the question arises as to how large a chunk of human activity this assigning meaning applies to. Three contenders are: i) GLOSSEMES, Bloomfield (1926) [5], ii) CONVENTIONS Lewis (1969) [32], and iii) MEMES Dawkins (1976) [11]. A *glosseme* is a segment of linguistic structure which has meaning. A simple definition of a *meme*, is an artificaly created, non-physical, perpetuating structure. The extent of a meme is nebulous, for example it can consist of single note in a symphony or to the idea of symphonies. The reason for introducing memes is to emphasize the analogy between the continuity of ideas held by a language community. This analogy can also be extended to virus, apparently an example of a 'mind virus' are chain letters, Goodenough and Dawkins (1994) [15]. Particular cases of memes are given by conventions, a simple definition of this is a rational self-perpetuating regularity. Lewis (1974) [33] takes the position that radical interpretation applies to all aspects of an individuals behaviour; this would include intentions and beliefs: meaning is sometimes expressed in terms of these Grice (1989) [17] p.96. Lewis (1974) [33] restricts himself to interpretation of an individual, although there appears to be no bar to applying it to a community. In this case interpretation would work not only for sentences but for all socially contrived structures: in particular memes and conventions would be subject to interpretation. There is a danger of having a circular chain of reasoning here, what if the assignment of extralinguistic information is itself subject to interpretation. Provided such "self-interaction" is small it should not interfere with interpretation.

5 Co-operation Dominance

5.1 Deliberately Misleading Ploys Lead to Co-operation Dominance

Radical interpretation depends crucially on there being a mechanism by which extralinguistic information can be used to give truth values to sentences. To discuss this begin by noting that in radical translation the natives might deliberately mislead the anthropologist for a variety of motives. For the translation to work deliberately misleading occasions must be in the minority or be detectable by the anthropologist. This observation is elevated to a principle, here called *cooperation dominance* which can be simply defined as the disposition of people to earnestly cooperate preponderating over alternative modes of behaviour. Traditionally, linguistic cooperation dominance has been referred to as the *principle of charity* and it has been thought necessary to invoke it so that sentences can be given truth values. Quine (1974) [42] p.328 attributed the phase principle of charity to N.Wilson. Lewis (1974) [33] p.338 holds that it is a collection of several sub-principles. The principle of cooperation dominance ensures that cooperation predominates, this essentially "DRIVES", (alternatively "optimizes the process of" or "forces coherence of") radical interpretation and results in meaningful language. The accuracy and speed at which this occurs is positively correlated with fitness for survival thus ultimately radical interpretation is driven by biological evolution. The actual mechanism by which radical interpretation occurs might be autocatalytic, Roberts (1999) [48].

5.2 Ploy and Counter-Ploy

Radical translation is one of at least eleven related topics involving DECEIT/COOPERATION and its evaluation. No detailed comparison is given here. To list the eleven in no special order: i) *radical translation* as discussed in the previous paragraph, ii) accounting for *coterie language*. An example is Cockney rhyming slang. This apparently developed to confuse immigrant workers about the intentions of native (Cockney) workers in the east-end docks, iii) evaluation the *credibility of communication.* Social psychologists Ravin and Rubin (1976/83) [44] p.176, study the credibility of communication, which entails gauging how useful and truthful communication is, iv) accounting for *animal deceit.* The collection of papers in Byrne and Whiten (1988) [7] discuss devious behaviour by animals and together these make a good case that the reason human intellect evolved, was in order to enhance social manipulation and expertise in preference to the prosaic explanation of greater ability to collect food and avoid predators, v) accounting for *human cognitive abilities.* As pointed out by Pinker and Bloom (1990) [40] p.724, the possession of language is an enormous advantage that biological evolution will select for strongly. The reason is that it allows communication of a large amount of information which aids survival - this leaves open the nature of the useful information. Survival can be enhanced sometimes by cooperation and sometimes by selfishness and the interplay of these two factors as great impact leading to a "cognitive arms race" Pinker and Boom (1990) [40] p.725. vi) accounting for *irrationality.* On occasion people do seem to make decision that are disadvantageous to themselves, Kahnemann et al (1982) [25], to reconcile this with the principle of cooperation dominance it is necessary to assume that people behave rationally with greater frequency. A reason for this could be that the experiments of Kahnemann et al isolate context in a way that is only discernible to the patient; at first sight it might not be rational to persevere with the contrived nature of the experiment. vii) *nonconsequentialist decisions*, Baron (1994) [3] are made by some people regardless of their judgement of what the consequences might be. viii) accounting for *stupidity.* Attempts have been made to define stupidity Welles (1984) [56], his definition requires nonrational behaviour, this occasionally has survival advantage; the reason for this is that it enhances social cohesion in a peer group. Non-rational behaviour has also been discussed by Shermer (1997) [49]. ix) using *game theory* to explain behaviour. The interplay of cooperation and deviousness might be quantifiable using game theoretic methods: game theory has been used in the behavioural sciences for example by Maynard-Smith (1984) [35], and also by Glance and Huberman (1994) [14] who find that the amount of cooperation is inversely proportional to group size. x) evaluating *relevance.* As argued in the fifth point communication allows transfer of large amount of useful information: for it to be useful suggests that it is in some way relevant. From this point of view the principle of cooperation dominance is just a generalization and extension of the *maxim of relevance* entertained by Grice (1989) [17] p.27, as relevance ensures speedy communication of information. xi) various *biological altruistic* approaches Hamilton (1964) [18] and Trivers (1971) [55].

6 Comparison of the Theories

6.1 The Counter-part to Natural Selection

A *correspondence theory*, Ramberg (1989) [43] Ch.4, is a theory that attempts to elucidate a relation between language and the world: the meanings of the language are called *intensions*, and the elements of the world are called *extensions*. Now assume that a correspondence theory of language is correct for a significant segment of natural language. In both biological evolution and radical interpretation there is an optimization process occurring, in biological evolution it is the optimization of a species to fit its environment through natural selection, in radical interpretation it is the optimization of the correspondence between intensions and extensions. Thus just as populations which are not fit are selected against, correspondences which are inaccurate are selected against. Similarly there is the notion of *coherence* which means the tendency of meanings assigned to a segment of language to develop in a way which increases self-consistency; thus coherence appears to have the idea of selection already contained in its definition. At this point it should be emphasized that we are attempting to explain language meaning as opposed to linguistic diversity, Renfew (1994) [45] and Hurford (1998) [24]. Linguistic diversity is concerned with how specific language structure spreads, geographically or otherwise. Language meaning is concerned with how a segment of language carries meaning. Perhaps the two notions are related and furthermore it might be possible to quantify by how much. This might be done by appealing to colour terms, Berlin and Kay (1969) [4]. Assume the description of the eleven focal colours to be given by eleven noemes, now the spread of the noeme and the corresponding word can be compared. To summarize the counterpart of biological natural selection is the increase of accuracy of both correspondence and coherence.

6.2 Mutations

Mutations in biology have counterparts in language; the straightforward counterparts are given by words that have occurred through speech errors (such as blends) later being adopted by the language community. Mutations account for biological diversity but not all, and perhaps not even a significant part of, language diversity can be accounted for by appealing to speech errors. Language is creative and at first sight it is hard to accommodate this creativity by appealing to mutations. It may well be that creativity can be accounted for by having a large number of mutant ideas and then discarding the majority of them, but this would be hard to verify. To summarize mutations do occur in language, but that the content of the language mainly originated by creativity, whether creativity can be accounted for by mutations is an open question.

6.3 The Smoothness of Change

In biological evolution change can be gradual or proceed by punctuated equilibria. The question arises as to whether an interpreter's interpretation of a language changes gradually or via punctuated equilibria. Consideration of this question depends crucially on the time-scale involved: here long time scales (of the order of years) are called *coarse-grained*, and short time scales (of the order of seconds) are called *fine-grained*. **First** of all consider this question on the fine-grained scale. Radical interpretation proceeds by assigning truth values to sentences, consider the input of a single sentence and the co-occuring assignment of a single truth value. Before the utterance there would be one *fleeting theory* of the language and after it another; thus the theory of the language jumps discontinuously by a discreet amount: hence on the fine-grained scale the theory proceeds via punctuated equilibria. This conclusion is dependent on the extralinguistic information assigned being a two-valued (or bi-valent) quantity. Discontinuous jumps will also occur if the extralinguistic information comes in integer valued packets; however if it is a real-valued quantity (or quantities) then continuous gradual change might be possible. Davidson (1984) [10] p.279 says:

> No doubt we normally count the ability to shift ground appropriately as part of what we call 'knowing the language'.

From the fine-grained perspective the skill in making small adjustments and shifting ground appropriately would be the same as knowing the language, however there is no existent psychological mechanism to demonstrate how this is done, or how it might manifest itself in consciousness. **Secondly** on the coarse-grained time scale an interpreter is said to hold a *quiescent theory* of a language. This quiescent theory needs occasional polishing up and rarely substantial adjustments; the way the quiescent theory changes can be illustrated by the way that single words change meaning - a new word can be invented, in which case this part of the theory has a punctuated equilibrium, however this has just a small impact on a small section of the theory; hence the quiescent theory usually proceeds by gradualism. In the Elizabethan era Shakespeare, Jonson, and others added thousands of new words to the

English language; as this is on the coarse-grained time scale it effects the quiescent theory. Whether this is an example of a quiescent punctuated equilibria depends on the quantity of change thought to be necessary for such a classification. Previous writers, e.g. Ramberg (1989) [43] p.102, hold that an interpreter at a given moment holds a *passing theory* of the language. The above Davidson quote suggests to me that a passing theory is the same as what I have called a fleeting theory, and furthermore that this is adjusted every time that an utterance is heard, i.e. radical interpretation of the fleeting theory is an actively occurring process in normal speech.

A similar distinction has been made in language acquisition Campbell (1979) [9]. Several time scale terms are used here. The first is the *microgenesis* of the language, which is the rapid, moment-by-moment nature of everyday language processes, by virtue of which we understand and produce utterances on a time scale that is marked off in seconds and milliseconds. In contrast there is the *macrogenesis* of language, this can either refer to an individuals learning of a first or subsequent language (the *ontogenesis* of language) on a time scale of days, weeks, months and years; or to a species development of linguistic abilities (the *phylogenesis* of language) on the time-scale appropriate to human evolution.

6.4 Metaphor as Exaption

In biological evolution exaption means new uses for parts originally adapted for other purposes. Let the counterpart of the exapted parts be words, or more accurately in the present context the meaning of words. Words are given new uses other than their "original" use in metaphor. For example in the metaphor 'the mouth of a river', mouth can be considered to be an exapted word. Of course "exapted word" is now itself a metaphor: the point in making it is that it highlights that in both biological evolution and in language the use is both opportunistic and creative.

6.5 Spandrels

In biological evolution spandrels are parts which originally occurred as a secondary byproduct of primary structure. Letting their counterpart of the spandrelized parts be words is again an option, but a preferable one is to let the counterparts be phrases. Idiomatic phrases perhaps occur as a by-product of other structure, but a better example is puns where the secondary meaning of the pun can be thought of as a by-product of the primary intention conveyed by the sentence.

6.6 Homologues

Homologous words certainly occur. Camera, chamber, and comrade all have the same evolutionary origin in the Greek word **kamara**, but they now have completely distinct meanings.

6.7 Analogues

Analogous words also occur. Tetrads, verbeins, and basis vectors, terms used respectively by relativists, particle physicists, and pure mathematicians mean much the same. Examples of analogous words such as these can always be argued to differ in nuance; but the difference is slight and appears to be less that the difference between the precise functions of standard biological analogues such as the functions of fins of fishes and the paddles of whales

6.8 Convergence

Convergence between word meaning frequently occurs, for example between transitory and caducity. **Caducity** originally meant a tendency to fall, from the Latin *cadere* = to fall. ("The caducity of language, in virtue of which every effusion of the human spirit is lodged in a body of death.", attributed by the OED to M.Pattison (1813-84)). Note also that a words *sounds* may be identical in two languages and yet have completely different meanings, depending on the nationality of the listeners.

6.9 Susceptibility to Initial Conditions

In natural languages the meaning of the two distinct words will never converge to such an extent that they concur in meaning, because they will always have different nuances. An example of this is every time a language users reads a script written before the word had closely converged. Thus reticulate evolution between word meaning is not possible for natural languages. Now in a formal language it is possible to require by FIAT that two words have identicle meaning: thus at first sight reticulate evolution is possible for formal languages, however the position is more complex than this. Consider the definition of "DERIVATIVE" in mathematics, Thurston (1994) [53] p.163. There are many definitions possible, Thurston lists as his first seven: the infinitesimal, the symbolic, the logical, the geometric, rate, approximation, and the microscopic, - and as about the 37th: the cotangent bundle. There is a choice as to which - if any - is considered the primary definition and which are considered properties. Now if in a formal text two words are required to have the same meaning this can be thought of as a reflection of the view of the writer, experienced practitioners of the subject may have other preferences. Thus reticulate evolution of a solitary word in a formal language is only possible for an individual user of that formal language, for the community which uses the formal language reticulate evolution is not possible.

From the vantage point of an individual, the meaning of a sentence obtained from radical interpretation is unusual because there is little sensitivity to initial conditions. People who are related and have been subject to similar environments can have very different views, it seems safe to say that their ideas on what words and sentences mean will not vary substantially. From the vantage point of a language community, again there seems to be little dependence on initial conditions: for example language communities develop, presumably on occasion independently words to describe the focal colours, Berlin and Kay (1969) [4]. Susceptibility to initial conditions is important because of the role that initial conditions hold in dynamical theory. Dynamical systems theory is the mathematical theory which it is hoped will eventually be used to describe all time dependent phenomena. For its application to biological evolution see for example Hofbauer and Sigmut (1988) [20], for its application to individual word meaning see for example Hinton and Shallice (1991) [19], and for its wider application in theories of meaning see Hoffman (1987) [21].

6.10 No Counterpart to Commensurability

Kuhn (1970) [30] and Ramberg (1990) [43] Ch.9 discuss the concept of incommensurability, a simple definition of this is that the usage of a word becomes *incommensurable* when its meaning has substantially diverged into separate language communities. The definition begs the question of how substantially different and separate affairs have to be before it is allowable to apply the word incommensurable, and this is a difference from biological evolution where a naive view is that it is in principle, but perhaps not in practice, always possible to tell if a speciation has occurred, for example by seeing if fertile offspring can be produced from two strands. This naive view of speciation does not always hold (see the remarks on reticulate evolution at the end of section 3.1), the difference is more one of degree rather than an absolute.

6.11 No Counterpart to Speciation

In biological evolution speciation is the evolution of a new biological species. It is not clear what should be taken to be the counterpart of a species in language. At first sight a noeme might appear to be a good counterpart to a species; the reason this does not work is, again, that there are fairly clear criterion for when a new species has been formed, and there is no such criteria for when a new glosseme has formed.

6.12 No Counterpart to the Traditional Gene

For the purpose of our comparison we use the traditional naive definition of a gene, here called the traditional gene, as a minimal unit of inheritance of definite size and *information content*. Until 1945 the definition of a gene as a unit of inheritance was sufficient to cover all known genetic data, Lewin (1994) [31] p.70; however developments since then have shown this naive definition to be inadequate. The idea that a gene has a definite size is in fact incorrect, genes can disperse from their original cluster on a chromosone to new locations by chromosomal rearrangement, Lewin (1994) [31] p.731; thus a gene can no longer be thought of as a unit on a chromosome as it has been spread around. An example of indefinite gene size is given by the gene for fragile **X** syndrome which results in mental retardation in boys. This gene contains repeated sequence of nucleotides which can expand or contract. If there are relatively few repeats (say less than 20) then fragile **X** syndrome does not occur; however if many repeats occur then it the sequence occurs. The information content of genes is not fixed either. Genes vary and are becoming increasingly difficult to define. In the 1940's Beadle and Tatum proposed "one gene for one protein (enzyme)". When multi-subunit enzymes were discovered this definition was modified to "One gene for one polypeptide.". Then genes were found to code for RNA molecules that never were translated into proteins. Even if one just considers the genes that specify proteins, it is now clear that some genes code for just part of a polypeptide chain (e.g. in the case of antibodies) while others code for more than one polypeptide. In one tissue a particular stretch of DNA (a gene, on the old view) will code for one polypeptide while another time it might code for a different (albeit related) polypeptide of a different length. Finally, it is not possible these days even to predict with total accuracy what amino

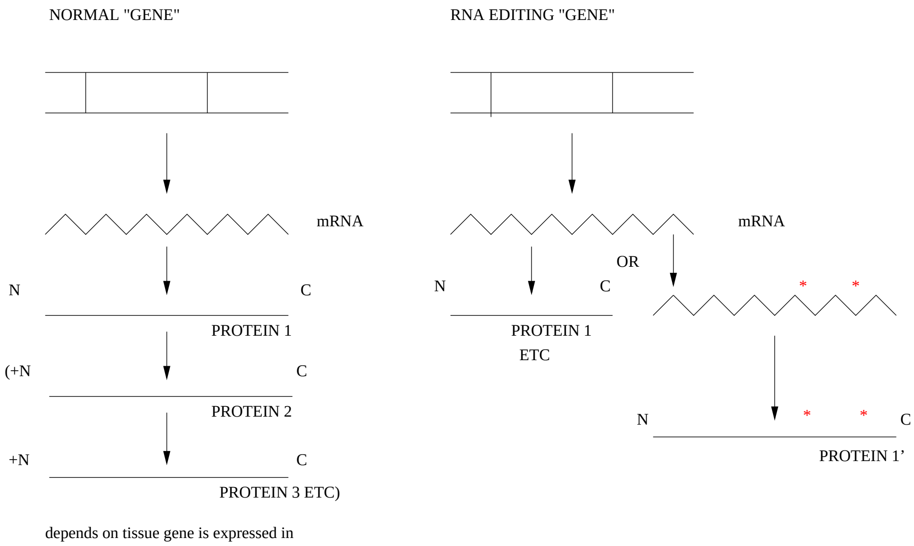

Figure 1: Editing of mRNA

acids in the polypeptide will be from the sequence of the "gene". This is because editing of the mRNA can alter the information content of the gene, as **Figure 1** illustrates, with the '$*$' indicating the edited mRNA:

Many textbooks just say that a gene is "a minimum unit of inheritance" but do not dare to say more as there are no further general rules. Even to say that genes are composed of DNA or RNA is probably inaccurate. Evidence for transmissible infectious agents that lack nucleic acids (Prions) is accumulating, see for example Lewin (1994) [31]. It may well happen that new concepts *emerge* from these consideration that suffice to explain the modern data and reduce to the concept of a traditional gene in some limit. It is curious to note that molecular biologists use the concept of words and languages frequently, for example gene libraries and dictionaries.

6.13 Compositionality

Once we have limited ourselves to traditional genes then it follows that memes, noemes, and similar constructions are fundamentally different from traditional genes, because traditional genes have a definite size and information content but the size of memes and noemes is indefinite. To illustrate the indefinite size of these objects begin by recalling the definition of a correspondence theory given at the beginning of section 6. Next define *com-*

positionality as the term used to say that the meaning of a sentence depends on the meaning of its parts, see for example Zadrozny (2000) [57]. This definition implies a restricted domain of applicability for a noeme. Compositionality must be at best only an approximation, because it does not take into account context. This has been noted by philosophers for example Davidson (1984) [10] p.22

> Frege said that only in the context of a sentence does a word have meaning; in the same vain he might have added that only in the context of a language does a sentence (and hence a word) have meaning.

6.14 The Antinomy of the Liar

It could be added that language itself is a changing structure, dependent on many aspects of the world, and that these should also be taken into account in order to say what meaning is; indeed it is not clear *a priori* what information could be excluded from a theory of meaning, and this implies that there can never be an absolute correspondence between language and the world. When considering the amount of language necessary for a truth it is straightforward to show that sentences are insufficient by constructing self-referential truth (**SRT**) sentences, such as the *antinomy of the liar* an example of which is "what this sentence says is not true". Now the way in which the truth of such sentences can be assigned is by taking into account sufficient context to disambiguate their self-referential nature. However the amount of language necessary for as theory of meaning cannot be disambiguated in such a manner, as the self-referential meaning (**SRM**) sentences: "This sentence is meaningless", or "What this sentence means is the opposite of what you think it means.", and the hybrid self-referential truth/meaning (**SRH**) sentence: "If this sentences is true then it is meaningless", show. The above suggests that meaning is more context dependent than truth.

6.15 Prefix Meaning

Appealing to context is a vague procedure without elucidating the nature of its component factors. On the other hand meaning can be assigned to small linguistic segments such as prefixes, for example BI-, TRANS-, etc., which certainly have some meaning associated with themselves, as for example given by the normative definitions of a dictionary. An analog of this is *content addressable memory*, which is the ability of people and some machine programs to retrieve information based on its contents rather than simply from an address. The more information which is available the easier it is to retrieve the rest: analogously for meaning, the greater the linguistic structure and context present the easier it is to assign meaning. A formal concept which perhaps encompasses both cases is *distal access* Touretzky (1990) [54], which is the ability to reference a complex structure via an abbreviated tag. Thus when it comes to assigning meaning to language the size of structure that this happens to is unclear. There appears to be nothing analogous a traditional gene; there is no unit between part of a word and a whole language that it is possible to say encapsulates meaning. Molecular biology shows the inadequacy of the traditional idea of a gene as having definite size and information content, thus the difference is more one of degree rather than an absolute - the absence of a unit is much more severe in language.

7 Conclusion

To summarize it is sometimes said that we lean by approximation: radical interpretation is a prescientific theory which hopes to describe and perhaps ultimately model how, by iterative approximation, we learn what meaning is. It is prescientific in the sense that it is not well enough developed to say what data would refute it - also there appears to be no alternative theory to judge against it. If a correspondence theory of language is assumed then radical interpretation is a process by which mental representations of the world become more accurate. Here it has been argued that radical interpretation applies not just to sentences, but to all socially contrived non-physical structure; in particular it applies to noemes, memes, and conventions. It was argued that radical interpretation is a typical time dependent process with the properties that, subject to certain qualifications explained in the text: on the fine-grained time scale it proceeds by punctuated equilibrium but on the coarse-grained time scale it proceeds gradually. Exaption occurs, an example being metaphor. Spandrels, homologues, analogues, and convergence also occur. Reticulate evolution can only occur in a formal language for an individual user where it can be introduced by fiat; this cannot happen for a language community using a formal language or for natural languages. Radical interpretation shows little sensitivity to initial conditions. Viewed as a time dependent process radical interpretation has more differences than similarities with biological evolution; the origin of this is that (for the purposes of pre-1945 biology at least) a convenient unit - the traditional gene, exists in biology, but no such unit can be found in a theory of meaning.

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