

An evolutionary model of language change and language structure

The formation of different languages and of distinct species, and the proofs that both have been developed through a gradual process, are curiously parallel...

Charles Darwin, *The descent of man* (1882:90)

2.1 Introduction

The relationship between language change and biological evolution has been debated since the emergence of linguistics as a science in the nineteenth century, at around the same time as the emergence of evolutionary theory. The debate has increased in recent times. One can identify three separate ways in which biological evolution has been connected to linguistic evolution in recent discussion.

First, interest has revived in the evolution of language, that is, the evolution of the human linguistic capacity (Pinker & Bloom 1990; Hurford, Studdert-Kennedy & Knight 1998; Kirby 1999). The evolution of the human linguistic capacity is a biological process: some biological change among ancestral primates led to the creation of a social and cognitive capacity for language or a language-like system for communication, and some process selected those primates with that capacity, leading to humans as a speaking species. This topic, while interesting, is also very speculative, and will not be surveyed in this book. This book is concerned with language change itself, not the evolution of a certain biological capacity of human beings.

Second, interest (and controversy) has arisen over the so-called genetic origin of contemporary human languages. Here the evolutionary connection is one of historical association. The internal structure of genetic linguistic families such as Austronesian are compared to the distribution of biological traits, such as alleles in mitochondrial DNA, or blood types (Bellwood 1991). It is assumed that, for the most part, transmission of biological traits through offspring is historically paralleled by transmission of language from parents to children, and hence family trees of human communities based on biological traits should roughly parallel family trees constructed on linguistic evidence.

Of course, all know that this parallelism in the history of languages and of human biological traits is not necessary. Languages are not transmitted via an individual's biological inheritance; only biological traits are. Rather, languages are transmitted to new speakers through exposure to their use. A group of people may abandon their language and adopt one of another group to whom they are not biologically closely related. For more recent families such as Austronesian, where the demographic history is better known, the relative contribution of language shift vs parent-to-child transmission can be more easily sorted out. In Austronesian, for example, it is clear that Melanesians are biologically closer to Papuans, and presumably have shifted to the Austronesian languages that they now speak (cf. Melton *et al.* 1995; Redd *et al.* 1995).

Relationships have also been observed between proposals for historically deeper linguistic families such as Amerind (Greenberg 1987) or even Proto-World (Bengtson & Ruhlen 1994) and proposals for historically parallel biological phylogenies (Greenberg, Turner & Zegura 1986; Cavalli-Sforza *et al.* 1988; Reich *et al.* 2012). These are much more controversial, chiefly

because of challenges to the linguistic classification. This book is primarily concerned with the mechanisms and processes of language change, not the origin and spread of specific families of languages; but we will consider the phylogenetic consequences of language change processes in chapter 8.

The third connection between language change and biological evolution is found where the theory of biological evolution itself has been adopted, or adapted, in order to construct an evolutionary theory of language change (see e.g. Keller 1990/1994:141–52; McMahon 1994:314–40; Lass 1990, 1997; Ritt 2004). Evolution is recognized as a process that occurs with certain types of entities. The process is probably best understood as it occurs with populations of biological organisms; that is evolutionary biology. The hypothesis that forms the starting point of this book is that language change is an example of the same process, or a similar process, occurring with a different type of entity.

Three main approaches have been taken to an evolutionary model of language change. The first approach is literal: language is a genetic capacity, and hence obeys certain principles of biology. This approach is associated with Chomskyan linguistics, because Chomsky argues for the biological basis of quite specific linguistic properties (e.g. certain syntactic structures and constraints). The literal approach also makes developmental claims: for instance, the hypothesis that the human language capacity in all its detail emerges in maturation.

However, the main goal of the literal approach is to claim a biological basis for the universal properties of languages. The ways in which contemporary human languages are divergent, and have diverged or will diverge in history, cannot be accounted for in the literal approach. A literal approach to language diversity would amount to claiming that the differences among languages reflect genetic differences among their speakers. This is patently false, as can be seen from the aforementioned fact that a person can learn a second language, and learns whatever language is spoken in their surroundings. For this reason, the literal approach generally turns to questions of the evolution of the human linguistic capacity, that is, what gave us the genetic basis for the properties common to all languages, whatever those may be.

The second approach is analogical: there are analogies between certain biological processes as described by evolutionary theory and certain processes of language change that call for description. Hence, linguists seeking better descriptions and analyses of those processes can borrow or adapt the descriptions and explanatory mechanisms that evolutionary biologists have proposed. However, no deeper claim is made about the relationship between the theory of evolution in biology and the theory of language change in linguistics. There are simply analogies or metaphors between a process in one domain of scientific study and a process in another domain. In the analogical approach, the relationship between evolution and language is essentially opportunistic – an opportunity for linguists to utilize some already developed theoretical constructs and practical methods.

For some linguists, the analogical use of evolutionary theory is fairly minimal. Despite the name of her theory (Evolutionary Phonology), Blevins explicitly denies that it is an evolutionary theory, and narrowly restricts the analogies from evolution that she employs:

Evolutionary Phonology is of course not a theory of language evolution based on natural selection. Though it is sometimes useful to draw parallels between the evolution of sound patterns and Darwin's theory of natural selection, these parallels are largely metaphorical, and are used [here] to highlight the non-teleological character of sound change. (Blevins 2004:18)

The use of the biological metaphor is more extensive in creole studies, e.g. Whinnom (1971) and especially the work of Mufwene (2001, 2005, 2008). Whinnom suggests that the biological concept of hybridization can be applied to language contact ‘provided that the analogies are properly applied’ (Whinnom 1971:91). Mufwene compares languages to species, but states:

I argue...that a biological approach to evolution is applicable to languages, although I must clarify at the outset that languages should be analogized to species rather than to organisms...I argue eventually that the approach is analogical only to the extent that it is inspired by scholarship on biological evolution...[Linguistic species] share properties with other species, biological and otherwise, while they also differ from the latter in interesting ways that are specific to their ontogenetic, architectural peculiarities (Mufwene 2008:1)

Lass appears to argue that there are limits to analogies from biological evolution to language change. Lass adopts an important concept in recent evolutionary theory, exaptation (Lass 1990; see §5.3 for further discussion). Lass writes: ‘while claiming that the notion of exaptation seems useful in establishing a name and descriptive framework for a class of historical events, I remain fully aware (even insistent) that languages are not biological systems in any deep sense’ (Lass 1990:96).

Analogies are useful, and they may stimulate a new way of thinking about a linguistic phenomenon. However, their utility is limited by the fact that they are only analogies. One cannot be certain whether an analogy that one has found is genuine. For example, I will argue that certain apparent analogies from biological evolution, such as the role of adaptation, are misleading. On the other hand, when one observes a disanalogy between biological evolution and language change, one cannot tell whether it can be safely ignored, or whether it undermines the whole idea of a theoretical relationship between biological evolution and language change. For instance, if there is no analog to DNA in language change, what does this imply about evolutionary models of language change? After all, for many biologists (though not all; see §2.3.3), DNA plays a central role in biological evolution. Does the absence of an analog to DNA mean that any analogies to biological evolution are hollow?

The third approach is a generalized theory of evolutionary processes. It is not that languages ARE biological systems in any significant way. It is that languages and biological systems are instances of a more general phenomenon: ‘rather than extending a notion from biology to linguistics, I am suggesting that the two domains ... have certain behaviors in common by virtue of evolving’ (Lass 1990:96). In the generalized approach, there is a profound relationship between biological evolution and language change, which is worth exploring in greater detail. The two are not identical by any means. But they both display salient properties that strongly suggests that they are instantiations of the same generalized theory that crosses disciplinary boundaries. Lass writes,

I am convinced ... that there is such a thing as a theory of “historically evolved systems”...A system capable of history or evolution must have a number of special properties: there must be ‘replicators’, items ‘heritable’ in some medium (biological, cultural, whatever); variation, i.e. imperfect replication, must be possible; and there must be a selection process (what particular kind is unimportant) that biases survival in favour of some particular variant(s) (Lass 1997:316, 112)

Lass, a historical linguist, makes some proposals here about what counts as a generalized theory of evolutionary change. A number of biologists and philosophers of biology have proposed generalized theories of evolutionary change. Not surprisingly, they take the process of

biological evolution as the starting point and abstract what they believe is generalizable to other domains, such as cultural change, conceptual change in science, and language change. Biological evolution is an extremely rich domain. Nevertheless, a view from outside biology may also contribute to what would be a truly domain-general theory of evolutionary change. Some aspects of a putative generalized evolutionary theory look very important to biologists, but are minor issues from the view of linguistics (or archeology, or social anthropology); and vice versa.

Non-biologists looking to biologists (or philosophers of biology) must also be aware that biologists are not in agreement as to what the essential ingredients of an evolutionary theory would be. Non-biologists, myself included, have been criticized for not drawing on the latest theories of biological evolution in developing theories of language change for example. But even a brief look at the literature reveals that not all biologists adhere to the latest theories of biological evolution either. Needless to say, this makes it difficult if not impossible for a non-biologist to find a generalized theory of evolution that would pass muster among all biologists. The next two sections will survey various proposed ingredients of a generalized theory of evolutionary change. At each step, phenomena from language change, and occasionally other types of cultural change, will be brought to bear, along with purported examples and counterexamples from biology.

2.2 The arguments in *The Origin of Species* applied to language change

Biologists still treat Darwin as a touchstone for the theory of evolution in biology. *On the Origin of Species* (Darwin 1859/1964) amasses a large amount and variety of evidence for Darwin's theory of evolution. The one major gap in Darwin's account had to do with what exactly were the "units of evolution". Perhaps Darwin was blessed in that respect, because this is precisely the most contentious issue in contemporary evolutionary theories, including generalized theories of evolution. Mesoudi et al. (2004) take advantage of this virtuous gap in *On the Origin of Species* and briefly review the major types of evidence that Darwin advanced for evolution in biology, and show that they all are found in cultural change as well. In this section, I will even more briefly review the same evidence for language. Mesoudi et al. follow Darwin's order of presentation (each section of their paper is introduced by a quotation from *On the Origin of Species*). The order of presentation here reflects the two main steps in the evolutionary process.

The first type of evidence is the existence of variation, upon which selection can act. Variation is a prerequisite for evolution to take place. Biological diversity and cultural diversity is enormous, as Darwin and Mesoudi et al. attest. Linguistic diversity is no different. There are approximately six thousand languages in the world at present (tragically, going extinct at a far greater rate than biological species). The grammatical structures of these languages, where documented, displays an incredible amount of diversity, as documented in grammatical descriptions of the languages and in the field of typology, the study of linguistic diversity and constraints on that diversity. Linguistic diversity is so great that it is impossible to establish any but the most general exceptionless, unrestricted universals of language (for some discussion of this diversity and its implications for language universals, see Croft 2001, 2010a; Evans and Levinson 2009).

I call crosslinguistic variation THIRD-ORDER VARIATION (Croft 2006), as it is the outcome of variation within the speech community combined with language divergence over time. Variation within the speech community is also pervasive. Researchers in sociolinguistics study what I call SECOND-ORDER VARIATION, namely variants of linguistic forms that are socially significant (e.g. Labov 1972, 2001). It is well documented in sociolinguistic research that individual speakers are

variable in their linguistic productions, using different variants in varying frequencies that reflect social factors, such as age, gender, social class or group, and the social context of use. This is best documented in sound structure (phonology), but also occurs in grammatical structures as well, and will be discussed in chapter 7. Less frequently discussed is the pervasive existence of FIRST-ORDER VARIATION, variation that occurs constantly but without (yet) acquiring social valuation. The advent of instrumental measurements in phonetics revealed the ubiquity of first-order variation in the phonetic realization of phonemes even within single individuals (Ohala 1989). Still less widely recognized is first-order variation in grammatical expression. Experiments in which different speakers described the same events (in a film, such as the Pear Film; Chafe 1980) demonstrate what is intuitively well known, that nobody describes the same events with exactly the same linguistic expression. Again, the degree of variability of lexical and grammatical expression even with a small sample of speakers is striking (Croft 2010b). First-order variation will be discussed in chapter 5.

A second type of evidence for evolution is the inheritance of traits. It is the inheritance of traits that allows for the selection of variant traits to have a lasting effect, in that traits selected for continue to persist while traits that are selected against disappear. Inheritance in language change is demonstrated by the ability of historical linguists to trace back sounds, words and grammatical constructions through the history of languages. The heritability of linguistic traits is also what allows historical linguists to identify language families and construct language family trees (phylogenies), and also to identify linguistic traits that were transmitted from one speech community to another via language contact.

A third type of evidence adduced by Darwin is the geographical distribution of species, by which he meant that the traits of species could not be explained purely by adaptation to the environment (see below), but only by descent. Parallel patterns of geographical distribution are found with languages. Many traits of languages cannot be explained by geographical contiguity or by the social structure of the speech community using the language. Instead, the traits reflect descent, and are similar to (or different from) other languages by virtue of common descent (or lack thereof). For example, languages of southern India possess similar linguistic traits by virtue of their being members of various subgroups of the Dravidian language family, regardless of whether they are spoken by large-scale urban literate societies or small groups of hunter-gatherers in the forest. The same languages bear similarities to Brahui in the distant northwest part of India because Brahui is another branch of the Dravidian language family.

A fourth type of evidence related to inheritance and descent is the accumulation of modifications. Variation in traits is inherited by its descendants; further variation in traits in the descendants is inherited by their descendants, and so on. Darwin uses the accumulation of modifications to show how complex biological structures can emerge gradually. Mesoudi et al. also provide evidence of the emergence of complex technology and mathematics through the accumulation of innovations over long periods of history. The same is true of languages: modern English differs dramatically from Old English (the latter being virtually uninterpretable to a modern speaker). But the history of English shows that the novel structures of modern English emerged from accumulated changes in the phonology, lexicon and grammar of the language over the centuries.

The four types of evidence presented by Darwin are all facets of one of the central and universally-accepted (as far as I can tell) principles of evolutionary theory: DESCENT WITH MODIFICATION. Certain entities form lineages through a process that is generally called REPLICATION (§1.1). The term ‘replication’ is a loaded one for many biologists, but it has been

used, with somewhat different meanings, in different evolutionary theories, including the ones to be discussed in §2.3. While there are important differences in the theories, what they have in common with each other and with Darwin is that there is a process that creates ancestor-descendant chains (that is, descent) that extend potentially indefinitely (these are the lineages); the entities on the lineage inherit traits from ancestors, but may also introduce some variation from the ancestral traits (this is modification); and the modifications accumulate. Lineages may also branch. Exactly what entities replicate, in biological or cultural or linguistic evolution, and what that replication process may be, is one of the major issues in evolutionary theories, and will be discussed in §2.3. In §2.6.4, we will return to what sorts of linguistic entities form lineages.

Mesoudi et al. discuss three other types of evidence for evolution from *The Origin of Species*. The first is competition: different individual organisms compete in the environment for key resources. Mesoudi et al. note that Darwin himself proposed that words compete in a language (Darwin 1971:91; Mesoudi et al. 2004:4). Mesoudi et al. generalize the notion of competition to apply to variants fulfilling functionally equivalent roles in a system, not restricted to competition for resources. Hence variant words—synonyms—are competing for the same functional role of expressing a particular meaning (Mesoudi et al. 2004:4). This is exactly how variants are defined in sociolinguistic research. Two grammatical forms represent ‘two ways of saying the “same thing”’ (Weinreich, Labov and Herzog 1968:162). The alternative ways may refer to sounds, as in different pronunciations of the same word (called phonological variables in sociolinguistics); words, as in the aforementioned case of synonyms; or grammatical forms, as in the alternative relative clause constructions found in *the girl that I met/the girl who I met/the girl I met*.

The critical factor here is that these forms are competing to express the same thing. This is the precondition for selection, a process by which one variant survives and proliferates, and the other variant(s) do not. This is the final step in the evolutionary process. The remaining types of evidence presented by Darwin, adaptation, convergent evolution and change of function, are taken to be the outcome of competition. Organisms that are better adapted to their environment are more likely to survive than organisms less well adapted to their environment. Similar environmental conditions may lead to different species evolving similar adaptations, such as wings for flying. And exposure to a new environment may lead to change in function, such as Darwin’s example of the swimbladder in fish becoming the lung in terrestrial animals (Mesoudi et al. 2004:8).

Mesoudi et al. observe that ‘cultural traits, such as clothing or farming practices, also commonly show a functional appropriateness to environmental conditions that has allowed humans to exploit an unprecedented range of habitats across most of the planet’ (Mesoudi et al. 2004:6). They also give examples of convergent evolution in technology, such as the invention of writing in the Middle East and Mesoamerica (and possibly independently in China), and examples of changes of function in technology (Mesoudi et al. 2004:8, citing Basalla 1988). In language, it has been argued that many sound patterns and word order patterns are motivated by adaptation to processing constraints in the production and comprehension of language (e.g. Hawkins 2004; Ladefoged and Maddieson 1996).

A greater degree of functional adaptation to the human environment (including the human-created environment) is frequently found in technological change. But this type of adaptation is not so obvious in other types of cultural change, such as changes in religious beliefs, changes in the decoration of artifacts, changes in dress fashions, and also much language change, such as the replacement of one word by another. In this respect, the similarity between Darwin’s arguments for evolution in biology and Mesoudi et al.’s arguments for cultural evolution do not match so

well. In sociolinguistics, however, it is argued that the most important environment for understanding language change is the social context of language use. In the competition of linguistic forms for a particular function (e.g. expressing a meaning), the outcome is largely determined by the perceived social status of the form, or at least of the speaker using the form (see chapter 7).

One of Darwin's chief goals in his theory of evolution was to explain how complex and well-adapted biological organisms could come to exist without invoking an external agent that consciously designed the outcome. The generation of variation via replication leads to incremental changes to the individuals, and competition among the individuals leads to selection of individuals with more adaptive traits over other individuals. These two processes, iterated over many generations, allows for the evolution of complex and changing adaptations over time. This is of course one of the major achievements of Darwin's evolutionary theory.

The novelty of Darwin's theory is that it provides an explanation of how complex adaptations can emerge different from appealing to a divine creator, but also different from more straightforward causal models of change (Hull et al. 2001:511). Another important characteristic of evolutionary theory as applied to cultural change, or language change, is that it provides a model of change that is not the result of the intentional behavior of individual persons. While individuals intend to do certain things, they do not generally intend to carry out collective cultural or language change across the society or speech community—and they often fail if they do intend to do so, as for example in the many failed attempts at spelling reform in English and other languages.

The evidence provided by Darwin for evolution in biology has parallels in cultural change and language change. The parallel evidence suggests that evolutionary change is broader than in biology. The question is, can a generalized evolutionary framework that subsumes biological change and cultural change, or at least language change, be made more precise? The primary controversy over answering that question is a major element missing from Darwin's theory, the "units of evolution" and the associated question of the nature of inheritance. The development of genetics led to the neo-Darwinian or evolutionary synthesis of genetics and Darwinian evolution. But the neo-Darwinian synthesis has been challenged as a theory of biological evolution. This leaves cultural evolutionists with a moving target in developing a generalized evolutionary framework, or even in using theoretical concepts and practical methods from biological evolution in the analysis of cultural evolution.

2.3 Towards a general framework for evolutionary change

The general phenomena that led Darwin to his theory of evolution are also found in cultural change, including language change. While these parallels are interesting, are they useful for biologists or linguists (or cultural historians)? It is not merely a case of taking a general theory of evolutionary change and applying it to language change. It should also be a case of taking language change and using it to help develop a general theory of evolutionary change. In either case, we must be more specific about the theory. Much of this section will be devoted to debates within biology and philosophy of biology about the nature of evolution. In most cases, I will be asking whether the issues they debate illuminate problems in language change. In some cases, I will suggest that language change (or cultural change) and other cultural evolutionary processes can play a role in constructing a general framework for evolutionary change.

Darwin observed heritable variation among individuals, and heritable variation plays a central role in Darwin's theory of evolution. But theories about the mechanisms of inheritance have

changed dramatically since Darwin's time. The first major development was the emergence of genetics. Genetics provided a mechanism for inheritance, and with the discovery of DNA and its structure, the material basis for genes was also discovered. The result was that two biological entities, genes as well as organisms, played a role in evolutionary theories, instead of just one. The gene-organism contrast also formed the basis for generalized theories of evolution. But the story in biology is not so simple; there have been "post-synthesis" elaborations—or challenges—to the simple view of evolution and inheritance. The implications of these developments for a generalized theory of evolutionary change depend on which biologist one follows.

2.3.1 *Dawkins: replicators, genocentrism, and memetics*

Richard Dawkins is one of the most influential evolutionary theorists for both biological and cultural evolution. Even those who disagree with him—and they are many—define themselves against his theories, or choose to attack him, even decades after the publication of *The selfish gene* (Dawkins 1976) and *The extended phenotype* (Dawkins 1982b). This phenomenon is of course familiar to linguists, since Noam Chomsky plays the same role to both fans and detractors. From the perspective of theories of cultural evolution and language change, we may identify two contributions that Dawkins has made to the debate, one widely accepted, the other widely rejected (or at least highly controversial).

Dawkins' more widely accepted contribution is providing a name for the lineage-forming entity, the replicator, and the explicit enumeration of its properties (mostly following Darwin). The formulation of the discussion of Darwin's theory in §2.2.1 anticipated Dawkins' formulation, not least by using the term 'replication'. Dawkins defines replicators in terms of a set of properties. We can divide Dawkins' properties into two groups, one involving lineage structure, and the other involving replication as a process.

The first property associated with lineage structure is lineage formation. Replicators must do more than make "copies" of themselves; the copies must also be replicators capable of producing further copies (Dawkins 1976:16-17). The result is a lineage. This is of course central to Darwin's theory of evolution. The second and third properties are longevity and fecundity (ibid., 18). These properties allow for differential survival of replicators: some last longer than others (longevity), some produce more copies than others (fecundity); some do both. These correspond to the notions of survival and reproduction in Darwinian evolution, specifically survival long enough to reproduce and continue the lineage.

The properties associated with replication as a process are also based in Darwin's theory of evolution. The first is that replicators produced by replication possess much of the structure of the "original". Dawkins describes this as "copying" (Dawkins 1976:16). Most other evolutionary theorists use the more neutral term of heritability: the new replicator inherits properties of its "parent", but the exact process by which this occurs is left open. The second and third properties are seemingly contradictory. On the one hand, the replication process must be largely faithful in passing on structure (Dawkins 1976:18-19). This is why the process is called "replication". On the other, variation—differences in structure from the "parent"—must also happen. Most important, that variation must be heritable. This allows variation to be cumulative. Again, this is central to Darwin's theory of evolution (§2.2.1). Without variation, selection has nothing to operate on, and without heritable variation, selection does not lead to evolution.

The concept of a replicator with the properties described in the two preceding paragraphs is widely accepted in evolutionary theory. Of course, these properties are essentially all in

Darwin's theory of evolution; this may be why they are widely accepted among biologists. Dawkins generalizes this concept, manifested by coining the abstract, non-biological term 'replicator'.

Dawkins uses his concept of replicator to build his "selfish gene" theory of evolution in biology. This theory is highly controversial. Dawkins argues that the only replicator in biological evolution is the gene, because it is the only thing that is copied (in the narrow sense of that term) with high fidelity (Dawkins 1976:36). He focuses on the properties of replicator survival (longevity and fecundity) and fidelity to argue that genes are "immortal" (ibid., 37). He argues that organisms serve solely as vehicles to help ensure the survival of genes (Dawkins 1982a). Genes build organisms as survival machines (Dawkins 1976, ch. 4). Genes, in other words, are in complete control. Genes are the replicators. Genes are the units of selection; it is the differential replication of genes only that matters. We may call this theory GENOCENTRISM. Although Dawkins gave a name to the role that organisms play—vehicles—he did not intend this role to be significant. He writes, 'I coined the "vehicle" not to praise it but to bury it' (Dawkins 1994:617). Dawkins also extends the concept of phenotype—the organism and its traits—to include other entities produced by the organism, such as nests and burrows, since these also are ultimately built by genes to ensure their survival (Dawkins 1982b).

Genocentrism is far more controversial, and it has been heavily criticized by the evolutionary theorists discussed in §§2.3.2-2.3.3. As a biological theory, it is argued to be both too broad and too narrow: too broad in attributing everything to the "selfish" interests of the gene, and too narrow in allowing only the gene to be the replicator and the target of selection. Genocentrism is often associated with genetic determinism, the view that the phenotypic traits of an organism are the direct result of its genetic makeup. In fact, environmental factors greatly influence the development of an organism and hence its phenotypic traits (see §2.3.3). Also, many parts of the DNA sequence, which is supposed to be the physical manifestation of genes are neutral, that is, they appear not to be influenced by selection (as far as we know). Dawkins is not a genetic determinist (Dawkins 1982b, ch. 2). However, it cannot be denied that Dawkins believes in the centrality of genes to evolutionary processes, even if other factors are allowed to play a role in gene "expression".

Dawkins also applies his replicator concept to cultural change. He proposes that there are cultural entities, which he calls MEMES, that are replicated and can be replicated differentially. Dawkins defines a meme as 'a unit of cultural transmission, or a unit of imitation' (Dawkins 1976:206).

Dawkins' initial view of what could count as a meme was catholic. Memes included: 'tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches' (ibid.); 'popular songs, stiletto heels...Jewish religious laws' (ibid., 209). These examples indicate quite a variety of possible cultural replicators. They fall into three broad categories. The first are ARTIFACTS, such as stiletto heels. The second are BEHAVIORS, such as ways of making pots or building arches. The third are CONCEPTS, such as ideas or Jewish religious laws.

These three types of possible cultural replicators are ontologically of different types. Artifacts are material objects. Behaviors are actions or processes. Concepts are mental entities, although they are presumably somehow implemented neurally, as a pattern of neural connections or a pattern of neural activation (see §2.3.2 for further discussion). Artifacts are closest ontologically to the neo-Darwinian or Dawkinsian gene, by virtue of their material reality. However, they are only a subset of the types of cultural phenomena that exhibit the characteristics that are parallel to the evidence for evolution in biology (§2.2).

Some cultural entities live a double or even triple life. I did not include language (catch-phrases, popular songs) or music (tunes, popular songs again) under the three-way classification given above. Language and music are behaviors, that is, they recur when a speaker produces an utterance or plays a tune. However, both produce transitory auditory entities, namely vibrations of the air. Acoustic signals are not traditionally thought of as artifacts, but linguists transcribe them and reify them for study as if they were artifacts. And a written text or musical score are undoubtedly material artifacts of language and music respectively. Audiovisual media allow for other sorts of behaviors (dance, theater, film, as well as linguistic and musical performances) to become artifact-like as well. Linguistic units also involve meaning, and hence also appear to involve concepts as well as behavior or artifacts. Many behaviors involve artifacts, for example hunting with a bow and arrow, wearing a polka-dot tie, or playing a bagpipe. The same artifact may be involved in different types of behaviors, for example, manufacturing, purchasing or playing a bagpipe. Conversely, multiple artifacts may be associated with a behavior, for example the musical score used to perform a Haydn quartet and a CD recording of that performance.

If we are to generalize an evolutionary theory to apply to cultural evolution, some position ought to be taken regarding these different ontological types of possible cultural replicators. In memetics, the theory of cultural evolution initiated by Dawkins (1976), there has been a split as to what counts as a valid cultural replicator. In later work (Dawkins 1982a), Dawkins restricts cultural replicators to be only concepts; he is followed by Blackmore (1999, 2000) and Aunger (2002), and in linguistics, by Ritt (2004). In this approach, artifacts and behaviors are merely “meme-products”.

Benzon (1996) and Gatherer (1998) argue that concepts cannot be replicators, and restrict cultural replicators to observable entities, namely artifacts and behaviors. Bazon reverses the relationship between artifacts/behaviors and concepts; concepts are analogized to the phenotype (Benzon 1996:323-24). Bazon notes that artifacts can be replicated in another culture but the conceptual apparatus may not go with it; he gives the example of Western-style Christian weddings in Japan, adopted even by non-Christian couples.

Gatherer offers a pragmatic argument against concepts as replicators. Concepts are unobservable. We do not know their neural structure and they cannot jump from one person to another without some observable entity, namely an artifact or a behavior (such as producing a word) intervening in the replication process. We can observe the structure of artifacts and behaviors, and thus analyze their evolution. We can also quantify artifacts and behaviors in a way that we cannot do with concepts. Sociolinguists and historical linguists regularly quantify tokens of language occurring in recorded utterances or written documents for analysis of their evolution. Concepts can be quantified only in terms of the individuals who have them. But in language change at least, a single speaker uses alternative variants of a linguistic form (see {sec}).

There are arguments that can be made in favor of either side in this debate. But each side has a complementary flaw. If cultural evolution involves replication, there needs to be a replication process. In each side of this debate, the replication process is indirect and mediated by the other. Concepts cannot be replicated across individuals unless there is some observable behavior and/or artifact by which another individual may imitate or learn the concept. Artifacts and behaviors cannot be replicated unless a human who has acquired the appropriate conceptual knowledge and skill does the replication. One cannot escape this quandary by choosing either concepts or artifacts/behaviors as the cultural replicator. A generalized theory of evolution applied to cultural change must be able to address this indirect replication process in some way.

The problem is not solved by the importation of genocentrism to the study of cultural evolution in memetics. Memocentrism is mainly practiced by those who argue that concepts are the only cultural replicators (beginning with Dawkins 1982a). Concepts are analogized to viruses that “possess” the persons who have the concepts (Dawkins 1976:207); memes are also selfish (ibid., 214-15). Persons are merely the vehicles for selfish memes to take over and steer towards their own replication.

The weakness of memocentrism as a theory of language change (or cultural change) is that it is based on importing domain-specific models from biology into linguistics, not the construction of a domain-independent theory of evolutionary change. The relationship between a cultural replicator (whether concepts, behaviors or artifacts) and human beings is different in too many particulars from the relationship between seemingly parallel entities in biology. For example, the relationship is not the same as that between genome and organism. There is no one-to-one relationship between cultural replicators of any type and a human being. A single human being can have multiple concepts, and certainly multiple behaviors and multiple artifacts, with the same function. For example, I have used the words and constructions in this sentence multiple times in my lifetime. The relationship between cultural replicators and human beings is not like biological development either.

The memeticists recognize this, of course. But they turn to another biological relationship, the virus-host relationship, to model the cultural replicator-human being relationship. This model is also not very useful. It is true that viruses do not have a one-to-one relationship with their hosts. But viruses in biology are material entities that literally do jump from host to host. The virus-host relationship therefore does not capture the fact that concepts cannot leap directly from one mind to another, or that learning a behavior or how to create and use an artifact requires the mediation of conceptual knowledge and skill.

A truly general model of evolutionary change will have to be abstract enough to allow some or all of artifacts, behaviors or concepts to serve as replicators forming lineages. It will also have to be abstract enough either to generalize over the relationship between cultural replicators and human beings as well as the relationship between genes and organisms (or viruses and hosts)—or else strike this relationship from the generalized model.

2.3.2 Hull: replication, environmental interaction and the General Analysis of Selection

In the introduction to §2.3, I noted that genetics appeared to provide a solution to the problem of the mechanism of inheritance. The result, however, was that now there were two central entities in biological evolution, the gene and the organism. More precisely, in the neo-Darwinian (synthesis) model, the genes of an organism constituted its genotype, while the organism itself constitutes a phenotype of traits or characters that are “expressed” by its genotype (to use the unfortunate linguistic metaphor commonly found here).

Of the various challenges to the neo-Darwinian synthesis (surveyed in Sterelny and Griffiths 1999), perhaps the most challenging is the question of the “units of evolution” or “units of selection”. In the standard view found in the neo-Darwinian synthesis of evolutionary theory in biology, it is the organism that is the unit of selection. Selective processes, of whatever sort, operate on the level of the fitness of the organism. Although it appears that it is genetic material that is ultimately replicated and then generates a new organism in reproduction, it is the organism

which is ultimately selected in the evolutionary process, by virtue of its (successful or unsuccessful) interaction with its environment.

As we saw in §2.3.1, the organism selectionist view was challenged by Dawkins (1982a, 1982b). Dawkins argues that the gene, not the organism, is the unit of selection—not just the unit of replication. However, the complications for the units of biological selection do not end there. Others have argued that selection may occur at other levels as well. It has been argued that selection might occur at the species level, or even at higher taxonomic levels. For example, it has been suggested that a species may possess a population structure that favors its evolutionary survival (Hull 1988:420–1, citing Vrba 1984). It has also been suggested that the geographical range of a higher taxon makes it more likely to survive a mass extinction, no matter how many species are contained in the taxon (Hull 1988:220, citing Jablonski 1986, 1987).

Still worse complications ensue when we abandon our zoöcentric view of evolution and ask ourselves at what level of organization does natural selection operate for cloned groups of plants and single-celled organisms:

botanists distinguish between tillers and tussocks, ramets and genets. For example, many sorts of grass grow in tufts (tussocks) composed of numerous sprouts (tillers) growing from the same root system. Which is the ‘organism,’ each tiller or the entire tussock? More generally, botanists term each physiological unit a ramet, all the ramets that result from a single zygote, a genet. Sometimes all the ramets that compose a single genet stay attached to each other; sometimes not. (Hull 1988:417)

The basic problem is that the divisions between the levels of organization for organisms is not at all clear, once we go beyond animals: ‘The hierarchical boundary between organisms and groups of organisms is no sharper than that between genes and organisms, in fact much less so’ (Hull 1988:418).

Hull (1980, 1988, 2000; Hull et al. 2001) draws two conclusions from this debate, and the biological facts that underlie it, in developing a generalized theory of evolutionary change. First, he argues that there are two distinct roles in evolutionary theory whose biological fillers are being disputed. Second, he argues that these two roles may be played by different biological entities, all at the same time. In both of these respects, Hull’s theory differs radically from Dawkins’ theory. Hull’s General Analysis of Selection is intended to include both biological evolution and conceptual change in science. Because of this double intention, Hull also grapples with the issues in cultural evolution raised at the end of §2.3.1.

Hull argues that there has been a convergence in the two approaches in the gene vs organism selectionist debate as they have refined their positions. Hull quotes an organism selectionist, Mayr, and then a gene selectionist, Dawkins:

as Mayr (1978:52) has emphasized tirelessly, ‘Evolution through natural selection is (I repeat!) a two-step process’ ... According to the terminology that Dawkins (1982a, 1982b) now prefers, evolution is an interplay between replicator survival and vehicle selection. (Hull 1988:217; see also pp. 412–18)

In Hull’s view, the two steps involve two processes, replication of individuals and selection of individuals through interaction with their environment. However, in the paradigm case in biology, these two individuals are not the same: it is genes that are replicated and organisms that are selected – which ensures the survival of their genes.

Hull argues that the debate between gene selectionists and organism selectionists is largely a matter of emphasis as to which process is more important. Hull argues that both processes are necessary, and it appears that prominent advocates on both sides of the debate accept this: ‘Since the ... dispute over the units of selection broke out, all sides have come to accept the distinction between replicators and interactors, albeit not necessarily in the terms I am urging’ (Hull 1988:413).¹

Hull’s two processes are replication and environmental interaction. Replication corresponds to the first of the two processes described in Darwinian evolution in §2.2.1, and the process given that name by Dawkins. (Hull adopts Dawkins’ concept of replicator but abandons virtually all other elements of Dawkins’ generalized theory of evolutionary change.) The second process in Darwinian evolution is selection. For Hull, selection is a causal relation between replication and environmental interaction: roughly, environmental interaction differentially causes replication. Thus, technically, there are three processes: replication, environmental interaction, and the causal relation going from the latter to the former.

Hull emphasizes that his model characterizes two causally connected processes, with no presuppositions as to what entities in biological evolution (or conceptual change) fill the central role in those two processes. However, the definitions that Hull gives in his earlier work are for the roles, not the processes. His definition of ‘replicator’ is given in (1) (Hull 1988:408):

- (1) ‘REPLICATOR – an entity that passes on its structure largely intact in successive replications’

Hull follows Dawkins and Darwin in identifying the core properties of replication as a process. The first is heritability/variation: structure must be passed on largely intact, but variation must also be able to happen in replication. Second, replication results in lineages: there are successive replications, and there can be multiple replicates of a single replicator.

Hull’s definition of ‘interactor’ is given in (2), and his definition of ‘selection’ in (3) (Hull 1988:408, 409):

- (2) ‘INTERACTOR – an entity that interacts as a cohesive whole with its environment in such a way that this interaction CAUSES replication to be differential’
- (3) ‘SELECTION – a process in which the differential extinction and proliferation of interactors CAUSES the differential perpetuation of the relevant replicators’

The process of environmental interaction is defined purely in terms of its role in selection: there is an entity that interacts with its environment that causes replication to be differential. The definition of selection given by Hull implies a more specific outcome of the interactor’s interaction with its environment: differential extinction and proliferation of interactors. Hull does not provide a definition of the environment in his 1988 book. The hypothesis that environmental interaction causes differential replication implies a joint contribution of interactor and environment. The only asymmetry between the two is the constraint that the interactor interacts as a cohesive whole. The environment is simply treated as the complement of the interactor in the interaction process that causes differential replication.

¹ Hull was perhaps being too generous to Dawkins; he acknowledges this (Hull 2000:54). For others who disagree, see §2.3.3.

An important aspect of Hull's General Analysis of Selection is that selection is a causal connection from environmental interaction (and hence the interactor) to replication (and hence the replicator). There is no relationship specified from the replicator to the interactor except that the latter are 'relevant' to the former. In the standard neo-Darwinian theory, the replicator is the gene and the interactor is the organism, and the relationship from gene (or genome) to organism is development. Hull does not limit the relationship between replicator and interactor to development:

Development is a common, though not universal, mechanism for relating replicators and interactors. Any entity that interacts with its environment in a way that makes replication differential is an interactor. Which causal relations produce this correlation is an open question, and development is not the only answer. (Hull 2000:53)

A correlation is required in order for environmental interaction to have a differential effect on replication, but how that correlation is produced is not specified by Hull. Of course, if the replicator and interactor roles are filled by one and the same entity, the correlation is automatic.

The General Analysis of Selection defines two distinct processes, replication and environmental interaction, with selection being a causal connection from the latter to the former. Replicator, interactor and environment are defined solely as roles in these processes. Hull's theory does not impose any restrictions of the fillers of these roles except that they must participate in the relevant processes of replication, interaction and selection as specified in (1)-(3). As a consequence, the General Analysis of Selection is a very abstract theory.

Hull's purpose in devising a generalized theory of selection is not merely to propose solutions to certain controversies in evolutionary biology. Hull deliberately makes his theory so abstract in order to capture commonalities between biological evolution and other evolutionary processes, in particular cultural evolution. He suggests that a misinterpretation of biological evolution has impeded application of evolutionary models to sociocultural evolution:

One reason for our tardiness in treating sociocultural evolution as a selection process is that most of us know a great deal about the vagaries of sociocultural transmission and have an overly simple view of biological transmission. If biological evolution were the neat process of genes mutating, organisms being selected, and species evolving, then sociocultural change is nothing so simple. One purpose of this chapter has been to show that biological evolution is not so simple either. In this chapter I have shown how general the characterization of selection processes must be if they are to apply to biological evolution. (Hull 1988:430)

The first corollary of Hull's abstract General Analysis of Selection is that the replicator and the interactor need not be one and the same. Hull argues that this is the case in the standard neo-Darwinian account of biological evolution. The replicator is the gene. It is replicated in the process of organismal reproduction when the relevant DNA is copied. The interactor is the organism. It interacts with its environment, and the result is selection: the differential survival and reproduction of organisms causes the differential replication of the relevant replicators, namely the genes of those organisms. Since the replicator and interactor are different entities, there has to be a correlation between the genotype and the phenotypic traits that is high enough to allow for selection to have an effect, assuming selection is operating.

One advantage of distinguishing the roles of replicator and interactor is that it allows one to distinguish certain types of evolutionary phenomena:

Once the distinction between replication and interaction is made, one can distinguish four possibilities: changes in replication frequencies due to interaction (directional selection), no change in replicator frequencies because the effects of the relevant variations happen, by chance, to balance each other out (balancing selection), changes in relative frequencies that are not due to any environmental interactions (drift), and replication sequences in which there are neither changes in replicator frequencies nor significant environmental interactions (stasis). (Hull 1988:443)

Distinguishing these types of evolutionary phenomena is also useful in understanding language change (see {sec}; Blythe and Croft 2012).

The second corollary of the flexibility of the roles of replicator and interactor is that different types of entities can be replicators and interactors: ‘Just as genes are not the only replicators, organisms are not the only interactors. Just as variable chunks of the genetic material function as replicators, entities at different levels of the organizational hierarchy can function as interactors’ (Hull 1988:417; see also Brandon 1990:88-98 for another analysis of biological interactors and replicators). Hull is liberal as to what can serve as an interactor in biological evolution. Even genes may be interactors as well as replicators, since they interact with their cellular environment at the molecular level. Hull writes, ‘Interaction occurs at all levels of the organizational hierarchy, from genes and cells, through organs and organisms, up to and possibly including populations and species’ (Hull 1988:409).

Hull is more cautious about what can serve as a replicator. Genes serve as replicators; they are copied in meiosis. If the population structure of a species can be heritable, then species might be able to function as replicators. Organisms are more problematic in Hull’s view. Cells may function as replicators and so may organisms if they reproduce by fission. Hull is skeptical that sexually-reproducing, multicellular organisms function as replicators for two reasons (Hull 1988:415). First, the replication process is indirect: the phenotypic properties of an organism are lost in reproduction and reconstituted in development. Second, phenotypic structure is passed on not very faithfully. The environment has a significant effect on the resulting phenotype in development. Hull argues that genes contain information that codes a potential range of phenotypic outcomes depending on environmental interactions in development (the reaction norm theory of genetic information). Since only one phenotype is actually realized, a large amount of the information in the gene is lost. Hull considers this loss to be too great for organisms to count as replicators. One consequence of this conclusion would be that organisms do not form lineages, since only replicators form lineages (Hull 1988:410).

Hull then applies his generalized theory of selection to conceptual change in the history of science. Hull argues that a concept is the replicator, that is, the equivalent to the gene in the neo-Darwinian biological gene-organism selection process (Hull 1988:441). The scientists play the role of interactors. The environment that scientists interact with consists of their empirical observations, their fellow scientists and the social context of science. Their interaction with their environment causes the replication of concepts, including variation in those concepts—new or modified ideas. The differential propagation of concepts—the amount of attention those ideas enjoy among scientists—causes the differential perpetuation of the relevant replicators—the ideas embodied in scientists’ theories. It is possible that conceptual lineages may converge if the two scientists criticize each other and refine their ideas in response to those criticisms. Again this is parallel to biological evolution; it occurs frequently among plants and other organisms (see chapter 8).

Hull’s General Analysis of Selection was developed to be abstract enough to provide a model for biological evolution and cultural evolution, in particular conceptual change in science. The

General Analysis of Selection is attractive for modeling cultural evolution, including language change, because of its separation of the interactor and replicator roles. Human beings function as interactors. They interact with their physical and social environment and thereby cause differential replication of cultural replicators. Hull's model does not specify what type of entities serve as cultural replicators—artifacts, behavior or concepts in the mind—any more than it specifies what type of entities must serve as biological replicators. (Hull allowed for artifacts, behaviors and concepts all to function as cultural replicators [David Hull, pers. comm.], although his theory of the history of science uses concepts as replicators, and he defends conceptual replicators against those who reject them [Hull 2000:58].)

Another advantage of an evolutionary framework as abstract as Hull's is to abandon the requirement of a one-to-one relationship between interactor and replicator, as found in the organism-genotype relationship in neo-Darwinian theory. Hull argues that specifics of gene-organism relationships in biology are not part of a generalized evolutionary framework, and should not be imputed to cultural evolution (Hull 2000:52-57). Concepts, behaviors and artifacts are replicated and form lineages that do not match the lineages of human beings as biological organisms (or their genotypes, if one rejects organisms as replicators). They are replicated at a much higher rate than human beings reproduce. Their lineages can “cross over” from one human being to another, and not necessarily from human biological parent to child. “Lamarckian inheritance” and “vertical vs. horizontal transmission” only make sense in a one-to-one gene-organism relationship (and in fact, both appear to happen in biological evolution). They do not make sense in describing the relationship between lineages of cultural replicators and human biological lineages. Nevertheless, cultural evolution is dependent on human beings. That dependence is the causal relationship between human environmental interaction and the replication of concepts, behaviors and artifacts.

Primarily for this reason, I adopted Hull's General Analysis of Selection in the first edition of this book and in subsequent publications (e.g. Croft 2002, 2006a,b; Baxter et al. 2006, 2009; Blythe and Croft 2009, 2012). Linguistic utterances represent replications of sounds, words and constructions of the language. Every time we open our mouths to speak (or use gestures, in both spoken and signed languages), we use sounds/gestures, words and constructions that have been used before, in either largely identical or altered form. These structures are spatiotemporally bounded individuals: tokens of linguistic structures in utterances. Language speakers are interactors. A speaker interacts with the experience to be communicated, her interlocutors, and the social context of the conversation.² That interaction causes her to produce (replicate) the sounds, words and constructions that actually come out. These conversations—linguistic interactions—bring about lineages of linguistic forms that undergo evolutionary change: the subject matter of historical linguistics, sociolinguistics and linguistic typology (see §2.2.1).

The interactor-replicator distinction is also useful in understanding other types of cultural evolution. Some scholars treat both artifacts and behaviors as cultural replicators. (A linguistic utterance is a behavior that results in the ephemeral artifact of the acoustic signal and/or sequence of gestures.) However, there are different behaviors associated with an artifact, and artifacts and associated behaviors may all function as replicators. Most linguists do not consider the written word to play a major role in language change (a position that should be seriously reconsidered, I believe); so I will use examples from music, another cultural phenomenon that

² Throughout this book, I will conform to the convention of using *she* to refer to the speaker and *he* to refer to the hearer.

involves a behavior—the performance—that results in an artifact—the musical composition—which can be made material in the form of a musical score and in the form of a recording of a musical performance.

The first type of evolutionary process in music is what is studied in traditional music history. For example, one can study the evolution of sonata form in Western classical music. This is the structure that is passed on in successive replications. The replicator is a classical sonata, produced by composers from the mid-eighteenth century to at least the early twentieth century. The sonata is a musical composition, an artifact made less ephemeral by the musical score. The interactors are the composers who selected the sonata form in which to compose their works. This particular musical form was differentially replicated in the late eighteenth and nineteenth century; it was popular among composers. The environment that influences the composer's choice includes fellow composers, predecessors and contemporaries, who chose the sonata form among other forms for their compositions; the performers, who were willing to perform such pieces; and the audience (including music critics), who attended those performances and judged the compositions.

The second type of evolutionary process in music is what is studied in the emerging discipline of music reception history. For example, one can study the interpretation of Beethoven's Ninth Symphony in performance and its reception since its première on May 7, 1824, from nineteenth century romanticism and increasingly large orchestral forces to historically-informed period instrument performances in the late twentieth century. In this process, the replicator is a performance (here narrowed down to the performance of one piece), i.e. a behavior. The interactors are the performers, who select the style and interpretation (and even instruments) to use in performing Beethoven's Ninth. The environment which influences the performer's choice includes fellow performers and their performances, available either directly or in recordings; and the audience, again including music critics and also music historians whose research is used in early music performance practice.

The advent of musical recordings (and before that, music scores) adds another set of processes that can be modeled in evolution. The same is true of writing and electronic media for language. Here we will describe two processes, which would make up an evolutionary model of economic behavior with respect to musical recordings. There are two types of economic replicators which are sometimes conflated into one: the manufacture of a product (say, a CD), which is a behavior resulting in an artifact; and the purchase of the product, which is a commercial transaction behavior that also involves the product/artifact. In the case of manufacture, the interactor is the manufacturer, whose business decisions result in the selection of various product types to manufacture. The environment that influences the manufacturer's product decisions includes the consumers (and their proxies, market researchers) and companies that produce competing products. In the case of the act of purchasing, which is itself the replicator, the interactor is the consumer, who selects which products to purchase. The consumer's environment that influences her choice is the product itself and its inherent qualities, but also other consumers and the purchases they made (or didn't make), as well as advertising which serves as a proxy for both.

Another cultural behavior that involves selection and evolving lineages is of course the use of an artifact, a behavior that is distinct from both the manufacture and purchase of that artifact. In this last case, the interactor is the user—in our musical example, the audience of a performance, heard live or played on a CD player. The environment that influences the person's choice to use the artifact includes the effects of the use with respect to the user's goals, and also other users.

All of these selection processes (environmental interaction plus replication) are interconnected, since what plays a role as part of the environment in one selection process may be the interactor in another process and the replicator in a third process. This is most likely a general characteristic of culture: artifacts and behaviors are linked together, and those interrelationships form parts of different selection processes in cultural evolution. In particular, the replicators and interactors in these different selection processes do not form hierarchies of part-whole inclusion of the sort often discussed in biology (gene, cell, organism, deme, species, etc.).

Hull's General Analysis of Selection provides a model for disentangling different cultural evolutionary processes and identifying their interconnections. However, important conceptual problems remain. The first is the indirectness of the cultural replication process. If one takes concepts to be replicators, as Hull does for the history of science, then they must be replicated by external, publicly observable behaviors: giving a lecture, engaging in public debate, or writing (and reading) a publication. If one takes behaviors/artifacts as replicators, as I have done with utterances in language change (and with music), then they must be replicated by a speaker via her knowledge of the language. Cultural replicators do not self-replicate; but nor do genes.

The problem here is not so much the indirectness of cultural replication, but Hull's contention that organisms are not replicators. Hull takes the fact that 'the overall structure of the parent organism detours through the genetic material' (Hull 1988:415) as an argument against organisms as replicators. But the detour of an artifact/behavior through a person's mental knowledge, or conversely the detour of a concept through public behavior, seems no different.

On the other hand, structure is 'passed on' in cultural replication. This is clearly so for artifacts and behaviors, but it is less obvious for concepts. We only know the structure of concepts through their external manifestation, typically in language. But the pattern of neural activation for linguistic units varies considerably among individuals, both within and outside the "core language areas" of the brain (Müller 2009:231-32), and early left hemisphere lesions may even lead to normal language development, localized chiefly in the right hemisphere (*ibid.*, 235). Partly for this reason, I treated the linguistic replicator as the external behavior and its result, the produced utterance, in the first edition of this book. This is in fact what most linguists study: the phonetic and grammatical structure of utterances, including their evolution over time. This is also what matters most to speakers in real language use. If the neural patterns in my head that lead to my producing and comprehending the passive construction in *Ted's bike was stolen* are different from those in your head, it doesn't really matter in conversational practice. What matters is that the construction's grammatical form is identical (as opposed to, say, *Ted stole your bike*).

Nevertheless, it has been argued that the linguistic structure of a physical utterance is not contained in the utterance, but only in the mind. In a critique of the first edition of this book, Ritt argues that analyzing an utterance's external form inevitably makes reference to mental constructs (Ritt 2004:158-59). Segmenting the acoustic signal into phonemes, morphemes and words, and identifying parts of the utterance as instances of particular constructions, all involves mental processes on the part of the speaker. For this reason, Ritt argues for concepts (mental structures) as replicators (§2.3.1).

With respect to grammatical form, Ritt's criticism does not lead inevitably to his conclusion that replicators must be concepts or mental constructs. Ritt is referring to the analysis of the physical utterance into parts, and their categorization, e.g. the phoneme /s/, the word *stolen*, the passive construction consisting of a subject phrase, a form of the verb *be* and a passive verb form

like *stolen*. It is true that the analysis requires a human being. But in the General Analysis of Selection, speakers do have a role, and that is as interactor. A speaker construes an utterance as a replication of certain sounds, words and constructions, based on her knowledge of her language and the conversational context (the environment). Her future replications of the same external entities are guided by the same factors. But the units that are analyzed and categorized are external.

Meaning, however, is another matter, and here Ritt's criticism is more serious. Ritt is right to say that the meaning conveyed in an utterance is generally taken to be part of the linguistic structure, especially so among linguists including myself who treat grammar as symbolic: a pairing of grammatical form and its meaning. It thus seems that for most linguistic replicators, they must combine linguistic form, which is external at least in part, and meaning, which is conceptual. So the division of labor between replicator and interactor in the General Analysis of Selection does not solve the problem of what counts as a cultural replicator.

In the next section, we will examine an approach to biological evolution that challenges a number of assumptions of the evolutionary models discussed above, and consider the contribution it can make to a generalized theory of evolution that can be applied to cultural evolution and language change.

2.3.3 Developmental Systems Theory, cultural evolution and language change

Developmental Systems Theory (Oyama 1985/2000; Griffiths and Gray 1994, 1997, 2001) arose as a reaction to problems with the neo-Darwinian synthesis of Darwinian evolutionary theory and genetics. It does not purport to be a generalized theory of evolutionary change. However, its challenge to the neo-Darwinian view of biological evolution has consequences for any generalized theory of evolutionary change that claims to include biological as well as cultural evolution.

The neo-Darwinian synthesis has little or nothing to say about development (Hull 1988:218; Griffiths and Gray 2001:195), in part because little was known about genes and development at the time (Hull 1988:202). The assumption in the neo-Darwinian synthesis is that somehow genes "code" for the phenotype; it is assumed that was the only way that natural selection operating on organisms could cause differential replication of the genes. What is now known about genes and development questions that view.

The first problem is that it is not clear what genes are in a theory of biological evolution. It was assumed that genes in a functional or instrumental sense, 'factors in the model of heritable transmission of a phenotype' (Griffiths and Stotz 2006:499), were physical pieces of DNA. However, the more is known about molecular biology, the less it turns out that this is the case, especially for eukaryotic organisms. Griffiths and Stotz provide many details about how the instrumental gene, as they call it, has a very indirect relationship to physical pieces of DNA. Only some examples will be given here. Even in classical genetics, it was recognized that a physical "gene" had a different effect depending on its position in the chromosome (Griffiths and Stotz 2006:503). The parts of the DNA that are transcribed may be spliced together from distant parts of the DNA sequence, and respliced in different ways (see the analysis of a wheat "gene" illustrated in Griffiths and Stotz 2006:512, Figure 1). Different genes may be transcribed from overlapping sequences of DNA, and DNA can also be "read" forwards and backwards in

transcription, with different results (*ibid.*, 510). The relationship between the gene in the instrumental, functional sense, and a physical piece (or pieces) of DNA is highly indirect:

...the gene has become a flexible entity with borders that are defined by a combination of spatial organization and location, the ability to respond specifically to a particular set of cellular signals, and the relationship between expression patterns and the final phenotypic effect. (Dillon 2003:457, cited in Griffiths and Stotz 2006:513)

Griffiths and Stotz write that ‘genes are defined by the way DNA sequences are used in particular cellular and broader contexts, and not merely by their structure’ (Griffiths and Stotz 2006:515).

These observations are of course highly relevant to language and language change, if not to cultural change in general. A physical linguistic utterance is made up of functional units representing linguistic categories (phonemes, morphemes, words, constructions). But those units are related to the temporally unfolding acoustic signal in as complex a way as instrumental genes are. Some phenomena, such as positional dependence, discontinuity, overlap and alternative interpretation (reanalysis in linguistic terms) are strikingly parallel (see §2.6.2).

These aspects of the postmodern gene also indicate that the neo-Darwinian theory of the gene as containing information that codes for the structure of the organism’s phenotype is problematic. The synthesis of “gene products”—the first step in the long process leading from a genotype to a phenotype—involves many other entities in the cell than the DNA. There is a very complex interaction between the genome, other entities and the environment in development. It has long been accepted even in the neo-Darwinian model of evolution that environmental factors strongly influence the development of the genotype into the phenotype. Even so, Hull and others following the neo-Darwinian theory of the relationship between genotype and phenotype have argued that the gene contains information that “codes” the phenotype in a way that the environmental factors in development do not (Hull 1988:415; Hull 2000:58-59; Hull et al. 2001:527, 561-63).

Developmental Systems Theory argues against placing any priority on the genome in development. Their argument is that non-genetic factors, including not just other entities in the developing organism but also the environment in which development takes place, are of equal significance in contributing to the phenotype of an organism. The core argument is that in any sense that a genome contains “information” about the resulting phenotype, the non-genetic factors also contain “information” about the resulting phenotype. That is, the causal relationship from genes to phenotype and from developmental environment to phenotype is identical in this informational sense. A simple example is the preference of young ducklings for the maternal call of their own species. It turns out that this is dependent on the ability to hear their own call in the egg; if they are devocalized in the egg, they do not develop this preference (Griffiths and Gray 1994:279). This phenotypic trait is the consequence of nongenetic processes in development, presumably in addition to some contribution from the genes: ‘a genetic cause will have its normal effects only if accompanied by suitable environmental conditions, and an environmental cause will have its normal effect only if accompanied by suitable genetic conditions’ (Godfrey-Smith 2007:112). Even those who adhere to the neo-Darwinian view that genes “code” for the organism’s phenotype admit that this is true (e.g., Hull 2000:58-59; see also Hull et al. 2001:527, 561-63).

From this observation, Oyama and Griffiths and Gray rethink the entire neo-Darwinian approach to heredity and evolution (the discussion here is based largely on Griffiths and Gray

1994, 1997, 2001, who give a clear and explicit account of Developmental Systems Theory). Development plays a central role in evolutionary processes in Developmental Systems Theory. Nongenetic and genetic factors are given parity in the development of the organism's phenotype. This includes factors that are traditionally attributed to the environment, including factors outside the organism such as the relevant aspects of its physical habitat and even the sun (Griffiths and Gray 1994:283-85). All of these form part of the developmental system.

Development is a process. Griffiths and Gray argue that the developmental process itself, that the life cycle, is the replicator (Griffiths and Gray 1994:291, 293; 2001:209). Life cycles can spawn other life cycles:

...tokens of the cycle [in a lineage] are connected by the fact that one cycle is initiated as a causal consequence of one or more previous cycles, and...small changes are introduced into the characteristic cycle as ancestral cycles initiate descendant cycles. (Griffiths and Gray 1994:291)

Life cycles form lineages, and can generate variation. Hence they are like replicators, that is, they satisfy the outlines of the definition of replicators described above. Griffiths and Gray (2001) avoid the term replicator, referring instead to evolutionary individuals (pp. 209, 214); we will return to this terminological issue below.

The developmental process draws on a variety of resources (also called interactants in Oyama 1985/2000 and Griffiths and Gray 2001). Some of these resources (such as the genes) are generated by the parental life cycle; others are created in the course of development; still others (such as burrows or beaver dams) are created by other members of the species; still others are persistent (such as sunlight). However, 'these distinctions, while real, do not bear on the type of role which the entity plays in the developmental process' (Griffiths and Gray 1994:291). What all resources have in common is that the developmental process involves interaction with them. Replication is then (re)constructing the developmental process found in the parent life cycle.

In Developmental Systems Theory what evolves is a interacting whole that includes both the organism and its environment: 'the developmental system of an individual organism contains all those features which reliably recur in each generation and which help to reconstruct the normal life cycle of the evolving lineage' (Griffiths and Gray 2001:207). The resources that form part of a developmental system outside of the organism correspond to what Brandon (1990) calls the ecological environment: 'those environmental parameters whose value affects the reproductive output of members of the lineage' (Griffiths and Gray 2001:206). Each organism has its own developmental system, since each organism uses a different set of resources.

The traditional division between organism and ecological environment is broken down by the fact that the organism modifies the environment as much as the environment modifies the organism in its development (niche construction; Odling-Smee et al. 2003). One consequence is that the concept of adaptation must be redefined, and this leads to the reframing of selection in Developmental Systems Theory.

Selection results in differential replication, and so one must move from 'the developmental system characteristic of an evolving lineage at a time' to 'an evolving population of individual developmental systems' (Griffiths and Gray 2001:207). Individual developmental systems will differ in their resources and the recurrence of those resources in descendant life cycles. Those differences may lead to differential replication of those life cycles. In traditional evolutionary terms, these differences will be differences in fitness. But fitness is not measured against an environment, as in Darwinian evolutionary terms (Griffiths and Gray 2001:208). Instead, the selectively significant differences between developmental systems are 'relative improvements in

their functioning' (Griffiths and Gray 2001:214). Developmental systems may also compete, if they utilize the same, limited resources (Griffiths and Gray 1994:301). Competition may of course also lead to selection. In sum, evolution is no longer 'change in gene frequency' (Griffiths and Gray 2001:195); it is 'change over time in the composition of populations of developmental systems' (ibid., 214).

Developmental Systems Theory remains a controversial approach to biological evolution. Nevertheless, it makes a number of important points about biological phenomena that tend to be overlooked in neo-Darwinian theories. The most important, of course, is restoring development to a central place in biological evolution. It also brings the environment into focus, by giving it parity with the organism and with genetic factors. Finally, it brings processes into prominence in their role in evolution.

What consequences does Developmental Systems Theory have for cultural evolution? Are the analyses of cultural evolution in current cultural evolutionary frameworks misguided and so must be discarded? Is a generalized evolutionary theory still possible? There is no doubt that Developmental Systems Theory and neo-Darwinian evolutionary theory clash in a number of critical points. Hull developed his General Analysis of Selection starting from the neo-Darwinian model, although he departs from it in a number of ways (for example, detaching the roles of replicator and interactor from the biological hierarchy). However, Hull made the General Analysis of Selection highly abstract, in order to be able to apply it to conceptual change in science, an instance of cultural evolution. The question then is: is the General Analysis of Selection general enough to accommodate alternative theories of biological evolution such as Developmental Systems Theory? (In fact, there is very little debate between these two in print; see Griffiths and Gray 1994:298, 2001:212, and more allusively, Hull et al. 2001:515, 561.) How much is the debate between neo-Darwinian evolution and Developmental Systems Theory internal to biological evolution?

Replication, in the sense of a partly structure-preserving, lineage-forming process, plays a central role from Darwin to Dawkins to Hull, and even to Griffiths and Gray. In Hull's interpretation of neo-Darwinian theory (see §2.3.2), a material object is the paradigm—and possibly only—instance of a replicator: the gene. (Hull recognizes the complex relationship between a functional gene and a physical strand of DNA discussed above; see also §2.6.) Although genes are replicators, they are not self-replicating. The structure of genes qua replicators contains information that somehow "codes" for the organism's phenotype. Genes are directly replicated, unlike organisms, which Hulls argues are therefore not replicators.

In Developmental Systems Theory, the replicator is a life cycle. A life cycle is a process, not a material object.³ A life cycle includes the organism as well as the results that guide its development; so in some sense the organism is the replicator, since it is the life cycle of an organism. The notion of information does not distinguish between genome and environment, and the gene does not have a special relationship to the organism phenotype in development. The replication process is not direct; the life cycle is reconstructed each time it is replicated.

Elements of an individual developmental system also replicate. However, the characteristic of an evolutionary developmental system life cycle is that it self-replicates. A self-replicating life

³ The difference between neo-Darwinian theory and Developmental Systems Theory may not be that great on this point. Brandon, in using the General Analysis of Selection in discussing the environment, writes, 'from the point of view of natural selection, phenotypes are dynamic, temporal entities' (Brandon 1990:50). And a life cycle is a life cycle of something.

cycle has ‘the intrinsic causal power to replicate itself’ (Griffiths and Gray 1994:300). This is possible because of the resources it inherits (not just the genome). Some replicators may be elements of a larger developmental system although they are not self-replicating (*ibid.*). A self-replicating life cycle may be contained in another self-replicating life cycle, as long as the larger cycle is characterized by having its own ‘events and entities whose numbers, proportions, and properties can be explained as the result of the differential replication of the larger life cycles in which they are involved’ (Griffiths and Gray 1994:294-95).

Replicators in neo-Darwinian evolution and in Developmental Systems Theory are thus quite different, and play different causal roles in their respective models of biological evolution. However, when Hull formulated the role of replicator in the General Analysis of Selection, he abstracted away from virtually all of these differences. The definition of replicator in (1), ‘an entity that passes on its structure largely intact in successive replications’ (Hull 1988:408), does not mention material being, information, or directness in the replication process. Thus it can accommodate a theory in which the replicator is a process, does not involve information, and replication is indirect, as in Developmental Systems Theory. Neo-Darwinian theory may be wrong about requiring these conditions for biological evolution; but these conditions are not required for replicators in the General Analysis of Selection. Nor does the definition of replicator in the General Analysis of Selection mention whether replication is self-replication or “assisted” (non-self-) replication. Developmental Systems Theory focuses on self-replication, but does not deny the occurrence of “assisted” replication of elements of a developmental system. Hence there is no incompatibility between replicators in Developmental Systems Theory and replicators in the General Analysis of Selection, even if there is incompatibility between Hull’s neo-Darwinian instantiation of replicators in biological evolution and the replicators in biological evolution posited by Developmental Systems Theory.⁴

As a matter of fact, the type of replicator posited in Developmental Systems Theory solves a persistent problem in theories of cultural evolution, namely what counts as a cultural replicator. Artifacts, behaviors, and concepts have all been proposed as replicators, and all suffer from weaknesses (§§2.3.1-2.3.2). But they can be unified in terms of a life cycle of a human cultural or linguistic act. Consider the example of the linguistic replicator that I have proposed: an utterance and its linguistic structure. The “life cycle” is an instance of language use: it begins with a mental state on the part of a speaker, continues through the production of the utterance—which includes the creation of the utterance as a type of artifact—and ends with the mental effects of the utterance on the speaker and hearer(s). This cycle is very complex, and will be discussed in more detail in chapter 4. But it unifies concept (the mental events and/or states—in particular the meaning of an utterance for both hearer and speaker), behavior (producing and comprehending the utterance) and artifact (the acoustic signal produced).

In the usage-based model of language (see also §2.6.3), this life cycle of an instance of language use can replicate. In the usage-based model, there is a feedback effect so that every use of language has an effect on the interlocutor’s knowledge of the relevant structures in the language. So every use of a linguistic structure in an utterance involves reconstructing the use of that structure (i.e. its life cycle) based on previous use of that structure. A similar analysis can be

⁴ Godfrey-Smith argues that information should not be part of the definition of replication: all that is necessary is that some structure be passed on in replication (Godfrey-Smith 2001; see also Godfrey-Smith 2007:107). Godfrey-Smith also acknowledges that reconstituting organisms (reconstructing life cycles) is an indirect process, though he does not want to call such an indirect process ‘replication’ (Godfrey-Smith 2001).

made in other domains of culture: internal concept and external behavior, often involving an artifact, together form the life cycle of a cultural act. The processes and phases in the life cycle of a human cultural act are of course different from the processes that make up biological development; each is domain-specific. What they have in common is the life cycle, and the fact that the life cycle can replicate (i.e., form a lineage).

The concept of a developmental system in Developmental Systems Theory, suitably generalized, also fits very well with the approach to language use adopted here. A developmental system is very similar to the notion of a complex adaptive system, described here for language:

(a) The system consists of multiple agents (the speakers in the speech community) interacting with one another. (b) The system is adaptive; that is, speakers' behavior is based on their past interactions, and current and past interactions together feed forward into future behavior. (c) A speaker's behavior is the consequence of competing factors ranging from perceptual mechanics to social motivations. (d) The structures of language emerge from interrelated patterns of experience, social interaction, and cognitive processes. (Beckner et al. 2009:2; see also Steels 2000).

The complex adaptive systems view incorporates all the resources utilized in language use, that is, the life cycle of a linguistic utterance and its lineage: speaker and hearer(s), including their shared and individual knowledge, beliefs and intentions; the conversational situation in both its social and physical aspects; the experiences to be communicated, and the joint actions between the interlocutors that they serve (see chapter 4); and the histories of the uses of the structures in utterances to which the interlocutors have been exposed. So in this respect Developmental Systems Theory is quite congruent with the view of language behavior adopted in this book.

An utterance does not appear to be self-replicating; it is an element of the self-replicating developmental system of a human being, which includes her socio-cultural as well as biological context. But an utterance lineage is not restricted to one person. The hearers also participate in the conversational interaction, and their future utterances will be replications of the “parent” utterance life cycle. The complex adaptive system that produces linguistic structures in utterances appear to be independent enough to be self-replicating, even if it is embedded in the biological self-replicating developmental system of human beings.⁵ Instead, utterances—and other cultural behaviors—qua cultural “life cycles” coevolve with human beings qua biological life cycles.

It can also be argued that linguistic structures in utterances are subject to independent evolutionary pressures from each other and from the speech community as a whole (if the latter is the best candidate for a self-replicating life cycle; see footnote 4). In the preceding paragraphs, I was deliberately vague about whether the utterance as a whole or specific linguistic structures in the utterance form distinct life cycles. Linguistic structures are coupled in utterances: sounds are combined into morphemes and words, and morphemes and words are combined into constructions. They typically evolve independently and under independent evolutionary pressures, whether those pressures are social or functional (that is, communicative or processing

⁵ If anything, the speech community is a candidate for a system that includes utterances and their linguistic structures as elements: it is self-replicating, although its history does not form life cycles. It is possible that a more explicit definition of ‘self-replication’, or one taking sociocultural change into consideration, may change this picture, and for example make utterances into mere replicators in the self-contained “life cycle” of the speech community. Even so, I would maintain that the best analysis of cultural and linguistic acts as replicators, self-replicating or not, is to treat them as life cycles in the generalized sense, self-replicating or not.

pressures). That is, sounds, words and constructions may each evolve independently of the other. In some cases, they do not evolve independently, and they can merge into a single linguistic life cycle (see §2.6.1 for examples and discussion).

Although Developmental Systems Theory treats life cycles as replicators, it rejects the distinction between the roles of replicator, interactor and environment that are found in Hull's General Analysis of Selection, and which appear to be useful for understanding language change and other types of cultural evolutionary processes. In the General Analysis of Selection, environmental interaction causes differential replication of replicators. This is the abstract definition of the selection process in (3) in §2.3.2: 'a process in which the differential extinction and proliferation of interactors causes the differential perpetuation of the relevant replicators'. Developmental Systems Theory denies a distinction between replicator and interactor (Griffiths and Gray 1994:298, 2001:212). However, this is really a denial of a distinction between genotype and phenotype, and of the notion that the genome contains information that somehow codes the structure of the phenotype. Hull follows neo-Darwinian theory here for biological evolution. But in his General Analysis of Selection, he only requires a correlation between replicator and interactor for selection to take place (Hull 2000:53, cited in §2.3.2).

Of course, if the replicator and interactor roles are played by the same entity, then the correlation is complete, and "coding" is not an issue. And in Developmental Systems Theory, the replicator and interactor are identical, namely the life cycle of a developmental system. Developmental Systems Theory does make a distinction between replication and differential replication. Replication is a property of a single developmental system characteristic of a lineage; differential replication is a property of the evolving lineages of a population of individual developmental systems (Griffiths and Gray 2001:2007). Again, while this characterization of differential replication and hence selection is incompatible with neo-Darwinian evolutionary theory, it is not incompatible with the General Analysis of Selection, if one equates 'environmental interaction' and 'the functioning of a developmental system'.

Developmental Systems Theory focuses only on selection of self-replicating systems, in which interactor and replicator are not distinct entities. This does not exclude the possibility of a causal relationship between distinct entities WITHIN a developmental system or a complex adaptive system such that the fate of one causes differential replication of the other. For example, in language change, an utterance has a life cycle of its own, and utilizes a range of resources, including the speaker, the hearer, the experience to be communicated, and the social context of the interaction. But an utterance is not self-replicating. The bottom line is that one of those resources, the speaker, actually produces the utterance. That is, the speaker directly causes replication to happen. That causal relationship allows for the possibility of selection (differential replication) of a replicator that is an element of the speaker's developmental system, namely the linguistic structures in the utterance, depending on the interactions of the speaker with the other resources in the complex adaptive system.

The same may be true of the genome in the developmental system of the organism. The genome is a replicator, albeit not self-replicating. It is part of the developmental system of an organism's life cycle. The differential replication of organisms, as a consequence of the relative effective functioning of their developmental systems, can cause differential replication of the corresponding genomes. The bottom line here is that the parent organism in the developmental system produces the genome and other material elements that serve as resources in the daughter developmental system. This may be what Griesemer has in mind in his reinterpretation of the replication process in Developmental Systems Theory as reproduction: for him, reproduction

requires material overlap (Griesemer 2000). If there is sufficient correlation between properties of the organism and the genome or other reproduced resources, then differential replication of the genome may be caused by the differential survival or extinction of the developmental systems of the organisms that contain the genomes.

The General Analysis of Selection calls this process selection. Developmental Systems Theory may not do so. For example, genome evolution may be analyzed to be so closely coupled to organism evolution that one should treat the two as an irreducible unit. Also, Developmental Systems Theory may consider selection only to apply to self-replicating replicators. But in cultural evolution, the evolution of utterances and other cultural life cycles is not as closely coupled to the evolution of a larger complex adaptive system, i.e. the society or speech community. In any theory of language change, the causal relationship from human being to cultural act is of central importance for understanding language change and cultural change in general. A generalized evolutionary model should include the causal relation between an interactor (perhaps better called a reproducer, following Griesemer) and the relevant replicators, even if this is downplayed or rejected by developmental systems theorists.

In this section, I have argued that the General Analysis of Selection is, for the most part, abstract enough to accommodate not only the neo-Darwinian theory of biological evolution and theories of cultural evolution, but also Developmental Systems Theory as a theory of biological evolution. The definition of replicator is broad enough to accommodate the life cycle and its evolutionarily significant properties. The role of interactor has nothing to do with the neo-Darwinian theory of development (contra Griffiths and Gray). Its role is defined in terms of selection of replicators, and may correspond to the reproducer as defined by Griesemer. Developmental Systems Theory does not appear to treat this process as significant, but it also does not appear to deny its existence either. In cultural evolution, cultural processes (“life cycles”) are the entities whose evolution we are most interested in. Hence, the role of human beings in reproducing those processes and selecting them in interacting with the resources available to them is an important aspect of cultural evolution.

If this interpretation is correct, then Developmental Systems Theory as a theory of biological evolution would not invalidate the General Analysis of Selection as a generalized theory of evolutionary processes in different domains (though it would invalidate Hull’s neo-Darwinian instantiation of the General Analysis of Selection in biological evolution). In fact, integrating ideas from Developmental Systems Theory into a generalized theory of language change (and cultural change) provides valuable insights for the latter. In particular, it solves the problem of what counts as a cultural replicator, and it is harmonious with the complex adaptive systems approach to human cultural behavior including language use.

2.4 Populations and lineages

Another major principle of the neo-Darwinian evolutionary synthesis is the replacement of the essentialist theory of species by the population or lineage theory of species (Dobzhansky 1937, Mayr 1942; see also Mayr 1982; de Queiroz 1998, 2005, who ultimately describes it as the ‘metapopulation lineage’ theory of species). Population thinking (as it is also called) does not appear to have generated the sort of controversies in generalized models of evolution that the “units of evolution” question has. It is, however, connected to the question of how to define species, which remains problematic. The population theory is also inextricably tied up with the question of systematics, that is, the taxonomic classification of organisms into varieties, species, genera, families and higher taxa, and the construction of phylogenies, that is, the history of the

divergence of species. Of course, all of these issues recur in language, with respect to the definition of a language and a speech community, and the (phylo)genetic classification of languages. I will argue here that the notion of a species is indeed problematic, but for precisely the reasons that population thinking would predict (this position is also argued for, in slightly different terms, by de Queiroz 1998, 2005).

2.4.1 Essentialist and population thinking for species and languages

In the ESSENTIALIST view of a species, species are defined by inherent properties of the individuals that make them up. Each species has immutable essential structural properties that identify it (Mayr 1982:256). In the essentialist view of species, a species is a type, defined by a set of properties, that is not located in space or time but in an abstract domain of biological traits. The instantiations of a species (its individual members) may be particular individuals, but the kind is not spatiotemporally bounded itself. Thus, an essentialist definition of a species is ahistorical.

The essentialist view of a biological species runs into problems due to structural variation among species, including high degrees of structural variation among individuals in a population and also among different life-stages in an individual in a population (for example, a caterpillar and the butterfly it turns into, or a species that changes sex over its lifetime; Hull 1988:430). The essentialist view also runs into problems with populations which cannot be distinguished by structural features but are distinct reproductive communities (Mayr 1982:271; see below). But the greatest problem for the essentialist view of a species is that a species evolves, and in so evolving, can lose ‘essential’ structural properties. Identifying this problem is one of the major contributions of Darwin to evolutionary biology.

The POPULATION theory of species is completely different from the essentialist theory (Mayr 1982:272). In this theory, species consists of a population of biological individuals. A population is a historical entity, and exists across time. When the focus is on a population’s existence across time, particularly a longer time interval, then the population is generally called a LINEAGE (de Queiroz 1998:60, 63; 2005:6602). Whether it is called a population or a lineage, the fundamental difference between the population/lineage definition of a species and the essentialist definition of a species is that the former is a historical entity whereas the latter is an ahistorical type.

De Queiroz argues that the many species definitions that have been proposed since around the 1970s all subscribe to what he calls the LINEAGE SPECIES CONCEPT. He traces the lineage species concept back to Darwin’s explication of the speciation process (Darwin 1859:116-25). A species is a lineage segment, that is, a population between a point of splitting of the ancestral population of the species at its beginning, and a subsequent population splitting event or the extinction of the population at its end (de Queiroz 1998, 2005). A species is a spatiotemporal individual, not an abstract essence. The population of organisms constituting a species is circumscribed by the region in time and space collectively occupied by the individual members of the species. The beginning of a species is defined by its branching off in a speciation process, and its end by either its extinction or its fission into two or more new species in speciation: ‘Just as the name “Gargantua” [an individual gorilla] denotes a particular organism from conception to death, “*Gorilla gorilla*” denotes a particular segment of the phylogenetic tree’ (Hull 1988:215).

As we saw in §2.3.1, lineages are a result of replication. Different types of biological entities replicate, or are claimed to replicate: genes (§§2.3.1, 2.3.2), organisms or life cycles (§2.3.3). In what sense, then, do populations form lineages? Or to put it differently, what defines a

population such that a species is (a type of) population? On this point, Darwin was not as clear (Mayr 1982:265–69; Hull 1988:96, 213 fn. 2; see Mayr 1982:272 for other precursors of population thinking). The neo-Darwinian synthesis was clearer on this point, at least for sexually-reproducing organisms: A population is a set of organisms woven together, so to speak, by the replicator lineages that join them via sexual reproduction. Where the fabric of interlocking lineages is rent, populations begin to split and separate species come to be born.

In population thinking, species are defined by a relationship that holds between the individuals in the population, and its absence between individuals of different populations. In biology, the relationship that holds between individuals in the population is interbreeding, and the absence of interbreeding is called reproductive isolation. What matters is actual interbreeding, or actual reproductive isolation, in the maintenance of a population or divergence of populations (as we will see below, actual reproductive isolation is not a categorical property, which is why defining a species is problematic). The interactional property that groups individuals into populations is interbreeding or reproduction. Reproduction is the property that causes replication (and differential replication, i.e. selection) to take place. The property that knits individuals together into a population is the property that forms lineages—a necessary consequence, since a population is by definition a lineage of interwoven organism lineages.

In the population view of species, there is no essential species type. Individuals can vary in enormous ways in physical structure (and behavior), but as long as they form a population in the evolutionary sense, they are members of the same species. Conversely, individuals may be structurally extremely similar, but if they come from two distinct reproductively isolated populations, they are members of different species. This is a radically different view of the species as a conceptual category. The category definition is based on a specific set of individuals, and category membership is defined in terms of how the individuals interact with each other, not by any inherent traits associated with all and only the individuals in the category.

If the population theory of species is distinct from the essentialist theory of species, then one would expect to find cases where there are mismatches in the world between species defined in terms of reproductively isolated populations and species defined in terms of essential structural properties. In fact, this is the case (see e.g. Hull 1988:104). SIBLING SPECIES are two reproductively isolated species whose structural descriptions overlap to such an extent that on an essentialist definition, they would be the same species. For example, five different species of the flower *Gilia* in the Mojave Desert are so similar that they were once classified as a single species, but the five species are highly intersterile (Grant 1981:61–2). POLYTYPIC SPECIES, on the other hand, are species that are structurally so heterogeneous that an essentialist would be hard put to categorize them as a single species, yet they form an interbreeding population (in terms of gene flow; Mayr 1982:287–92).

The mismatches occurring between the essentialist and population definitions of species are also found in Hull's theory of conceptual change. Hull subscribes to a lineage theory of concepts, not an essentialist one. In order to understand how scientific theories evolve, concepts must be treated as spatiotemporal individuals, in fact, lineages of ideas replicated from one scientist to another. For the understanding of conceptual change, what matters is the history of the concept, not its content. Two similar concepts with distinct lineages are distinct concepts, even if they seem alike from an essentialist point of view. The 'same' concept as 'discovered' by another scientist without knowledge of the conceptual lineage of the first scientist is, in Hull's view, a different concept, belonging to a different conceptual lineage. The phenomenon of 'reinventing the wheel' in science is not really reinvention, if the second scientist came up with the idea

independently. For example, the concept of the phoneme was invented several times, but only once did it catch on and was replicated in subsequent linguists' research and publications.

Conversely, two concepts that are different in essentialist terms are the same concept from a historical point of view if one is a later replication of the other and thus in the same lineage. As with organisms, ideas can change with each replication from scientist to scientist, even though they form a single lineage, since replication is not always identical. For example, the Prague school notion of markedness and Greenberg's notion of markedness in typology are quite different on essentialist grounds (Croft 1996b); but they are one historical concept in Hull's theory because Greenberg's notion was intellectually derived from the Prague school notion, as Greenberg acknowledges in his work (Greenberg 1966:11, 13). Hull's own theory is a further example. Although he adopts Dawkins' notion of replicator (which in turn is descended from Darwin), his generalized theory of evolutionary change is otherwise almost completely different from Dawkins'. This historical-entity view of concepts is radically different from the traditional essentialist one, where concepts have an immutable, eternal identity.

Finally, the mismatches occurring between the essentialist and population definitions of species are also found in languages. These are the standard examples of the problem in defining language and dialect (see e.g. Chambers & Trudgill 1998, chapter 1).

SIBLING LANGUAGES are two linguistic varieties that are structurally so similar that they are considered to be 'dialects of the same language', yet are perceived by the speakers – or at least by one group of speakers – as distinct languages. Examples of sibling languages (of varying degrees of controversiality) include Macedonian and Bulgarian, Danish and Norwegian, Serbian and Croatian, Hindi and Urdu, and Malay and Indonesian. Dixon (1980:33–40) points out that many instances of neighboring languages in traditional, small, decentralized, nonliterate societies such as Australian aboriginal societies involve what I call sibling languages. In some cases the perception of the sibling languages as distinct is not reciprocal: many Bulgarians tend to see Macedonian as a dialect of Bulgarian, but the reverse does not hold. Of course, this reflects different perceptions about the social and political separateness of the communities that speak these linguistic varieties.

POLYTYPIC LANGUAGES, on the other hand, are linguistic varieties that are structurally so diverse that linguists would characterize them as different languages, yet their speakers perceive them as dialects of the same language. Examples of polytypic languages include the Chinese so-called dialects: they are mutually unintelligible (Li & Thompson 1981:2), but the writing system and political unity tends to imply identification as a single language (Norman 1988:1–3). Another example of polytypic languages is found in DIGLOSSIA (Ferguson 1959/1972), where there are two related but mutually unintelligible varieties, the L[ow] variety being a vernacular and the H[igh] variety a written standard, as in German-speaking Switzerland or the Arab countries. Speakers perceive H and L as a single language, L often being perceived as a substandard or imperfect version of the H variety. The same is true of so-called postcreole continua, where the creole basilect and standard language acrolect are mutually unintelligible, as with Jamaican creole and Standard Jamaican English (DeCamp 1971:350). The structural diversity of traditional dialects of English, German, Italian and other western European languages may be instances of a lower degree of polytypy, depending on the degree to which their speakers identify themselves as speakers of English, German, etc., albeit nonstandard speakers.

Turning to the crux of the matter, the essentialist vs. population definitions of species, we find a parallel clash of definitions of a language. The STRUCTURAL definition of a language – if two

varieties share enough structure in common (phonology, grammar or morphosyntax, lexicon), then they should be classified as part of the same language – corresponds to the essentialist definition of a species. Comparison of linguistic varieties based purely on structural properties leads to assessments of language vs. dialect based on essentialist criteria. The structural definition of a language possesses the same flaw as the essentialist definition of a species. As I argued in §1.1, the structural definition of a language makes a type out of a historical entity. As with species, languages evolve over time, undermining the structural definition; and sibling languages and polytypic languages demonstrate further problems with the structural/essentialist definition of a language.

What is the linguistic equivalent of the population definition of species? Chambers & Trudgill (1998) offer a social definition of language as an alternative to the structural definition (see also Haugen 1968/1972). They define an **AUTONOMOUS VARIETY** as one that is perceived by its speakers as a distinct language, no matter how similar it is structurally to some other variety. A **HETERONOMOUS VARIETY**, on the other hand, is perceived by its speakers as being the same language as that of an autonomous standard variety, no matter how structurally distinct those varieties are. We may apply Chambers & Trudgill's definition to the cases of sibling languages and polytypic languages. Serbian and Croatian are examples of sibling languages. Serbian is autonomous from Croatian because Serbian speakers perceive their language as distinct from Croatian and vice versa. Modern Arabic is an example of a polytypic language. The colloquial varieties of Modern Arabic are heteronomous, because speakers of the modern colloquial varieties perceive their colloquial variety as a version of Arabic.

Chambers & Trudgill's social definition of language closely corresponds to the population definition of species. However, their definition is based on speaker perceptions (and the existence of a standard variety). The genuine equivalent to the population theory of species for a language must be in terms of actual communicative interaction. The linguistic equivalent to reproductive isolation is, unsurprisingly, **COMMUNICATIVE ISOLATION**: if people do not talk to each other, they belong to different speech communities. Conversely, linguistic interbreeding is communication: people who talk to each other belong to the same speech community.

The population definition of a language thus appears to be very similar to the notion of mutual intelligibility used to distinguish languages from dialects. However, mutual intelligibility tends to be defined in terms of potential communicative interaction, whether or not the speakers belong to the same speech community. Communicative interaction depends not only on the degree of structural similarity of the varieties spoken, but also on the social behavior of the speakers. Serbian and Croatian are mutually intelligible to a high degree, but many speakers do not communicate with the opposite community due to the recent political changes in former Yugoslavia.

The interactional property that holds a speech community together, and whose absence separates speech communities into distinct languages, is communication. As with species, the interactional property defining the population—conversing—causes replication of the linguistic replicators, utterances, to take place. What makes a speech community a speech community are the conversations that weave people together into a social unit. What makes a language a language are the interlocking lineages of linguistic structures replicated in the utterances of the speech community. Where the fabric of interlocking linguistic lineages is rent by (actual) communicative isolation, the speech communities and their languages will come to evolve separately, and this process can lead to the birth of new languages.

If we pursue an evolutionary theory of language following the lead of the evolutionary theory of biology, then we must take the population (social) definition of a language as the basic one. A structuralist linguist may feel uncomfortable about the social definition of a language. But the fact is that the social definition is the correct one from a historical perspective, in terms of causal mechanisms of language “speciation” (divergence). The social definition makes predictions of likely historical developments whereas the structural definition does not. Sibling species are likely to diverge morphologically as their reproductive isolation continues (see Hull 1988:66–7, discussing Mayr’s theory of speciation). Likewise, sibling languages are likely to diverge structurally as their communicative isolation persists. A polytypic species may break up if the gene flow is interrupted, or possibly become more homogeneous or at least maintain itself as a single species. A polytypic language may break up if its social unity is broken – this appears to be what is happening in the distinct modern Arab nations. Or it may survive as a single language as in China, possibly becoming more homogeneous, as with the loss of the traditional dialects of western European languages. Social and communicative isolation leads to structural divergence; social and communicative intercourse leads to maintenance of the status quo, or even convergence (which itself is a result of tighter social cohesion and mobility).

2.4.2 Gradience and gradualness in species and speciation, and in language and language birth

There still remains the issue of the recent proliferation of species definitions in biology. Why has this happened? De Queiroz (1998, 2005) argues that the recent proliferation of species definitions can be understood by distinguishing the species concept from species criteria. De Queiroz argues that all contemporary biologists subscribe to the the metapopulation lineage concept of a species (§2.4.1). Species are ‘groups of interconnected populations that form an extended reproductive community and an unevenly distributed but unitary gene pool or field for gene recombination’ (de Queiroz 2005:6601; the difference between metapopulations and populations will be discussed below). A metapopulation that evolves independently is a species (ibid., 6604). A lineage is simply a temporally extended perspective on a population.

The real “problem” with the metapopulation concept of a species, or of a speech community or a language, is that it does not provide sharp lines dividing species, speech communities or languages. The population definition of a species, a speech community or a language, is based on the actual lineage-forming interaction between individuals in a population, and actual lack thereof between individuals in a different population. But the fact of actual interaction or lack thereof does not perfectly unify a supposedly single species/speech community, or perfectly separate supposedly distinct species/speech communities. Reproductive isolation is treated in theory as a sharp dividing line, but it is not entirely so in fact (Hull 1988:102–3). Not every organism interbreeds with every other organism in the species, and not every speaker talks to every other speaker in a speech community. Over time, the process of isolation of individuals in diverging populations—and hence the separation of species and languages—is gradual.

Speciation—the splitting of populations—takes time, a point on which biologists appear to agree (de Queiroz 1998:70). The gradual nature of the speciation process gives rise to the plethora of contemporary species definitions. Contemporary species definitions are what de Queiroz describes as species criteria: criteria for deciding whether two diverging populations have separated enough to be called different species. For example, de Queiroz observes that although Mayr led the way in introducing population thinking and the metapopulation lineage

concept of a species to evolutionary theory, he also proposed a definition of a species in terms of ‘intrinsic reproductive isolation’, that is, absence of the potential to interbreed. But the only thing that matters in the population perspective is actual interbreeding, and actual reproductive isolation (cf. de Queiroz 2005:6606). Actual interbreeding holds a population together, and actual reproductive isolation may lead to the separate evolution of two lineages. Only actual interbreeding/communication ultimately matters for the population definition of a species/language.

The different species criteria do not point to the same stage of the speciation process as “the” point at which there are now two species or populations. But the important fact is that speciation (and language divergence) is gradual. It is a kind of Zeno’s paradox: at the beginning, all agree there is only one species or population; after a certain point, all agree that there are now two species/populations; but there is disagreement about what point one should declare that the split has happened. In fact, it is artificial to treat any one of the steps in the process as a sharp dividing line defining two distinct species (de Queiroz 1998:63-65, 70-73). All of the changes are significant in the speciation process.

To make matters more complicated, the process of divergence can be reversed, up to a point at least. Populations can come into contact and interact; even merger of populations (also described as RETICULATION of lineages) can take place. For example, there are many cases in which biological populations that were separated and then brought into contact again developed a stable hybrid region in between the two distinct populations. Hull gives the example of the hooded crow and the carrion crow in Europe: separated by glaciers which then receded, the species populations remain distinct, but there is a stable band of hybrids in a zone not exceeding 75 to 100 kilometers in width (Hull 1988:103). Hence there is interbreeding where there is contact, but there is little gene flow between the two populations. Conversely, reproductively isolated populations of plants can merge (called reticulation in biology; see chapter 8 for further discussion): ‘estimates of the proportion of plant species in general that are of hybrid origin run as high as 30 or 40 percent’ (Hull 1988:103; cf. Grant 1981:203).

Not surprisingly, there are linguistic parallels to different degrees of reproductive isolation such as the hybrid zone for carrion crows. Chambers & Trudgill note that there is a hybrid area in East Anglia between the Northern English vowel [ʊ] and the Southern English [ʌ], one of the most salient phonological markers of Northern vs Southern English (Chambers & Trudgill 1998:105–18). In the hybrid area, one finds MIXED and FUDGED varieties (lects in their terms; see §7.4.4). Mixed varieties possess [ʊ] in some words and [ʌ] in other words; fudged varieties use a phonetically intermediate vowel such as [ɤ] in some words. The mixed and fudged varieties form a transition zone between the Northern and Southern English varieties. Similar transition zones are found with bundles of ISOGLOSSES (geographical boundaries between one linguistic feature and another). For example, the boundary between French and Occitan is defined by a number of lexical and grammatical features. But the isoglosses for each feature do not match perfectly: there was a transitional zone across the middle of France where varieties possess some ‘French’ features and some ‘Occitan’ features (Chambers & Trudgill 1998:96, Map 7–6, after Jochnowitz 1973).

There are many far more complex situations in both biology and language. In biology, one finds ‘ring species’, where a population extends its range and gradually differentiates, but then the ends of the range come into contact and there is little or no interbreeding. This is essentially identical to the situation of a geographical dialect continuum (Chambers and Trudgill 1998:5-7),

in which a speech community spreads across a geographical area and is gradually differentiated: neighboring villages can (and presumably do) communicatively interact, but speakers at opposite ends of the dialect continuum cannot communicate (or at least not very well). However, the reality of most ring species is much more complex, with local isolation and recontact leading to differing degrees of gene flow between populations, as with the *Ensatina* salamanders in California (Wake 1997). A similarly fine-grained analysis of migration and interaction of speakers—especially in industrializing, urbanizing speech communities—would reveal parallel degrees of complexity of communicative interaction and isolation. In the biological case, it leads to disputes about how many species there are (e.g. Highton 1998; Wake and Schneider 1998; Kuchta et al. 2009). In linguistics, it leads to disputes about how many languages there are, particularly for speech communities lacking the social apparatus of a nation-state. Population thinking provides a causal explanation for the process of speciation and the phylogenetic history of biological and linguistic populations (including contact or reticulation; see chapter 8). Population thinking does not provide sharp boundaries for species or languages; but that is exactly the situation on the ground.

De Queiroz defined a species as a metapopulation, that is, ‘a group of interconnected populations’. This definition acknowledges that even within a species, not all individuals interbreed, or even have equal likelihood of interbreeding. Biologists distinguish species (de Queiroz’ metapopulations), geographical races and at the lowest level demes (corresponding to a single population in de Queiroz’ sense). A SPECIES is an interconnected group of interbreeding individuals. A GEOGRAPHICAL RACE is a subpopulation of a species which is defined geographically, and often has structurally diverged to a slight extent, but presumably not so far as to prevent interbreeding. A DEME or local population:

consists of organisms in sufficient proximity to each other that they all have equal probability of mating with each other and producing offspring, provided they are sexually mature, of the opposite sex, and equivalent with respect to sexual selection. To the extent that these conditions are met, the organisms belonging to a deme share in the same gene pool. Of course, in natural populations, some mating occurs between adjacent demes, and not all organisms within a single deme have precisely equal probability of mating, but the isolation between demes is met often enough and well enough for demes to play an important role in biological evolution. (Hull 1988:433)

These different types of populations are also relevant to the notions of language, (geographical) dialect and speech community, defined in terms of communicative interaction and social identity rather than in the essentialist terms of linguistic structure. A language and its speakers should be defined in population terms just as species generally are. A geographical race is a traditional geographical dialect: defined geographically, slightly divergent structurally, but not enough presumably to prevent communication (i.e. intelligibility) or to provide a separate sociolinguistic identity, assuming we are not dealing with sibling languages.

A deme is related to one definition of the complex notion of a speech community. A speech community can be defined as broadly as all of English no matter where it is spoken, at an intermediate level such as Hiberno-English, or as narrowly as a particular fairly cohesive social network such as the ones analyzed by the Milroys in Belfast (Milroy 1987). A SOCIAL NETWORK corresponds most closely to a deme: a group of people who are most likely to communicate with each other, and not so much with those outside the network. One can describe the results of the Milroys’ research in Belfast rather well by paraphrasing the Hull quotation and making the appropriate substitutions of sociolinguistic terms for biological ones (see chapter 7):

a social network consists of speakers in sufficient proximity to each other that they all have equal probability of communicating with each other, if they have some reason to linguistically interact. To the extent that these conditions are met, the speakers belonging to a social network share in the same language. Of course, in natural speech communities, some communication occurs between adjacent social networks, and not all individuals within a single social network have precisely equal probability of communicating with each other, but the isolation between social networks is met often enough and well enough for social networks to play an important role in language change.

Populations are individuals, in the sense of historically existing, spatiotemporally bounded entities. ‘Individual’ is taken in the broad sense here, so that spatially discontinuous entities (such as populations) are individuals as well, as long as the collection of entities is spatiotemporally bounded. Given the issues regarding the discreteness of species and of speech communities, and the gradualness of their divergence, the boundedness criterion may have to be loosened; but species and speech communities are still historical entities even if not entirely discrete. Taking the population view of species, a particular species is an individual: it has a beginning and an end temporally and it is also bounded spatially. Particular organisms and genes are also individuals, of course; so is a collection of plants growing from a single root stock; so are other population-based entities such as demes.

It appears that the assertion that evolutionary processes operate only on spatiotemporally bounded individuals is generally accepted among biologists and philosophers of biology, despite their disagreements on other issues discussed above. Selection operates only on spatiotemporally bounded individuals: ‘only an individual has what it takes to be selected’ (Hull 1988:215). Spatiotemporally bounded individuals are actual individuals, by definition, and therefore selection operates only over actual individuals: ‘In selection processes of all sorts, selection takes place among actual, not possible, alternatives’ (Hull 1988:473). In fact, however, rigorous application of individual and population thinking in cultural change, including conceptual change and language change, challenges some basic essentialist assumptions made in nonevolutionary approaches, as will be seen in the next section.

2.5 Applying the generalized theory of evolution to language

We may now use the generalized theory of evolution presented in §§2.3-2.4 to build a theory of language change (or indeed, of language in general). We begin by presenting definitions of the most important individuals and populations in language evolution. Our definitions resemble the definitions of these concepts used in nonformal linguistic theories, formal linguistic theories and philosophical theories of language, but differ from them in certain critical respects.

An **UTTERANCE** is a particular, actual occurrence of the product of human behavior in communicative interaction (i.e. a string of sounds), as it is pronounced, grammatically structured, and semantically and pragmatically interpreted in its context. Hence it is a cultural “life-cycle” as discussed in §2.3.3. This definition more or less conforms to the standard philosopher’s definition of utterance-token with the additional specification of its phonological and morphosyntactic peculiarities. An utterance is differentiated from a sentence, as the latter term is understood by philosophers, formal language theorists and syntacticians. A sentence is standardly defined in essentialist terms, as a type of grammatical and semantic structure; it is not a spatiotemporally bounded individual. An utterance as defined here, however, is a spatiotemporally bounded individual. Thus, unlike sentences, only actually occurring tokens count as utterances in our sense. It is critical to the theory of language change that utterances be actually occurring language; selection operates only over actual, not possible, alternatives. Since

an utterance is an actually existing entity, all levels of its structure are included, in particular its specific pronunciation and meaning in context as intended by the speaker and interpreted by the hearer (see §4.3.2).

A LANGUAGE is the population of utterances in a speech community. This definition appears to be quite deviant from the structuralist linguistics notion of a language as a system of contrasts of signs. However, the structuralist notion of a language as a system of signs is the embodiment of essentialist thinking (see §1.1, §2.4), and a population approach is necessary for attacking the problem of the nature of language change (and, for that matter, language itself; see §1.1). Thus, our definition of a language actually more closely resembles the formal language theory definition of a language. In formal language theory, a language is a set of sentences that is generated by a grammar. But our definition of a language differs from the formal language theory definition in two important respects. First, a language is a population of utterances, not a set of sentences. Second, our definition does not denote the set of all and only the sentences or utterance types that are generated (in the technical sense of that term) by a formal grammar. It is only the set of actual utterances produced and comprehended in a particular speech community. Again, this restriction conforms to the definition of a population: it is a spatiotemporally bounded set of actual individuals, not a set of ‘possible’ individuals.

A GRAMMAR is the cognitive structure in a speaker's mind that contains her knowledge about her language, and is the structure that is used in producing and comprehending utterances (the nature of this knowledge will be discussed further below). The grammar of each speaker is acquired on the basis of the subpopulation of the language that she is exposed to.⁶ Thus, each speaker will have a slightly different grammar. This definition is also based on the formal language notion of grammar but deviates from it just as our definition of language does. First, the grammar is not generative in the technical sense of ‘generate’ as characterizing a set of admissible sentences. This is because the grammar does not generate the language as described in the preceding paragraph in the formal language theory sense of ‘generate’. It cannot do so, because the language is not all possible sentences. On the other hand, the grammar (in our definition) does generate the language in the informal sense of ‘generate’: it is what a speaker uses in producing (some of) the utterances of a language.

Second, the grammar consists of all our mental capacity in the use of language. Some theorists argue that the processing mechanisms involved in producing and comprehending utterances are separate from the repository of grammatical knowledge (competence) in the mind. Others argue that a single, more or less integrated cognitive structure both ‘contains our knowledge of the language’ and is used for actually producing and comprehending utterances of the language. For our purposes, it does not actually matter whether the two are separated or not: what matters is that the whole mental apparatus is included in our definition of a grammar. Hence, our definition of a grammar does not correspond to only the competence module postulated by some linguists; it must include any processing modules as well. What is most important is that our definition of a grammar is a real, individual, psychological entity, not an abstraction that does not have a psychological (or physical) existence. In other words, a grammar as defined here is also a spatiotemporally bounded individual.

Now we may apply the generalized evolutionary framework to language. In §2.3.3, I argued that the generalized roles in the evolutionary framework are: the replicator, which is dynamic (a

⁶ So-called ungrammatical utterances have only a heuristic status in this theory, as one of several methods used by linguists to find out the structure of a speaker's grammar.

“life cycle”) and undergoes replication in the Darwinian sense; the interactor, which plays a direct causal role in the replication process; and the complex adaptive system, which is the system consisting of the replicator, the interactor (if different from the replicator), and the replicator’s resources or environment. Also, a replicator in one complex adaptive system may serve as a resource (or part of the environment) in another complex adaptive system, in the case of coevolving systems.

In a linguistic complex adaptive system, the replicators are found in utterances. Replicators are embodied linguistic structures, anything from a phoneme to a morpheme to a word to a syntactic construction, and also their conventional semantic/discourse-functional (information-structural) values. The replicator is the particular linguistic structure as embodied in a specific utterance. An utterance, or more precisely some aspect of the utterance, embodies a linguistic structure: a passive clause, say, or a closed syllable, or a particular encoding of a predicate–argument relation. The replicator is a spatiotemporally bounded individual, i.e. a token. It HAS structure – ‘[i]n order to function as a replicator, an entity must have structure’ (Hull 1988:409) – but it should not be identified with the structure as an abstract essence (type). The formal structure of e.g. the passive construction, or its semantic/discourse function, or the phonetic expression of a phoneme, can change in replication. In order to clearly distinguish the embodied replicator from the structure that it possesses, we must give it a name. Following a suggestion by Martin Haspelmath, I propose that the paradigm linguistic replicator be called a LINGUEME. Thus, the paradigm replicator in language is the lingueme. An utterance is made up of linguemes, and linguemes possess linguistic structure.⁷

When a speaker produces an utterance, she replicates a linguistic structure – actually, a large number of linguistic structures.⁸ In fact, the production of an utterance involves an extremely complex recombination of linguemes from a great range of utterance “parents”, far more complex than the two-parent recombination of genetic and other material in the reproduction of sexual organisms in biological evolution. When another speaker hears that utterance and produces another one, the structures are replicated again; this is one of the Darwinian properties of a replicator, the ability to have replication of a replication.

As noted in §2.3.3, not all replicators are self-replicating although they are part of a larger complex adaptive system, and this is also true of linguemes. The speaker functions as the paradigm interactor in language, in that she directly brings about the replication of the linguemes (§2.3.3). The speaker engages in communication when reproducing linguemes (see chapter 4 for a detailed description of this process); that is, she interacts with other speakers. After all, the lingueme is not just an embodied structure but part of a dynamic social interaction between speaker and hearer. This interaction defines the most fundamental population in language evolution: the SPEECH COMMUNITY. The members of the speech community, interacting with

⁷ The term ‘gene’ has an unfortunate ambiguity between token and type. A phrase such as ‘gene frequencies’ refers to frequencies of gene tokens. However, a phrase such as ‘the gene for hemoglobin’, refers to the type: many different individuals have ‘the gene for hemoglobin’. I am, unfortunately, going to continue this practice with ‘lingueme’. In virtually all uses in this book, ‘lingueme’ will refer to tokens; if I am referring to a lingueme type, I will use the phrase ‘lingueme type’.

⁸ In fact, Hull hints at this instantiation of the generalized evolutionary framework in language in a remark on the tokens of scientific terms in their use in scientific discourse: ‘Term-tokens themselves change in replication sequences, e.g. sequences of allelomorph-allelomorph-allelomorph gave way to allele-allele-allele. This sort of transition is the subject matter of historical linguists’ (Hull 1988:505; see also Keller 1990/1994:147; Mufwene 1996a:85).

each other, produces the population of utterances, that is, the language of the community. Thus the language is defined by the population of speakers and hearers that produces it.

The population of utterances in turn defines the population of linguemes that are contained in the utterances. This last population we will call the LINGUEME POOL. The set of linguistic conventions represented by the replicable structures of the linguemes in the lingueme pool of a language is the evolutionary equivalent to the language system (see §1.1). But the evolutionary concept of a language system is not essentialist. The conventions vary and change as a result of variation in replication and of selection. And conventions are defined by the speech community: an identical lingueme structure in another language is not the same convention in the evolutionary framework (cf. Rohde, Stefanowitsch & Kemmer 1999). Finally, linguemes coevolve, and this coevolutionary processes are the manifestation of language structure in the traditional linguistic sense of that term (see §2.4.3 below).

The complex adaptive system of lingueme replication includes as resources the paradigm interactor, namely the speaker (re)producing the linguemes; the other members of the speech community with whom the speaker reproducing the linguemes interact; the social context of the speech event; the goals of the speech event itself; and the other linguemes in the utterance in which the lingueme is replicated, and with which the lingueme in question coevolves. These are all of course historical entities playing roles in the evolutionary process.

A grammar – a speaker’s knowledge about the language – is acquired through hearing other utterances embodying these linguistic structures. Knowledge of language is essentially the ability to replicate linguemes in the appropriate social-communicative contexts.⁹ The grammar used by the speaker is a real existing mental entity: it must be able to interact with a real physical/mental/social environment. Since grammars are historical entities – what each member of the speech community knows about her language – every speaker’s grammar is slightly different, and no speaker’s grammar is “complete”. But in an evolutionary, non-essentialist, approach to language, there is no such thing as “completeness” in the sense of producing all possible sentences of a language. A language is spatiotemporally bounded, but for any speaker in the speech community, that boundary is not closed until the last speaker dies. Since speakers also generate variation and are creative in language use, no grammar can be “complete” and indeed no language is “complete” until the speech community goes extinct. For this reason, I describe a grammar as a speaker’s knowledge ABOUT her language, not OF her language.

Although the concept of genes as replicators, or more precisely the concept of gene as a bearer of biological structure, is disputed (see §2.3.3), there is an important phenomenon associated with genes (or whatever it is that leads to the development of biological structure) that is highly relevant to language evolution. In order to skirt the biological controversy, I will begin by describing the linguistic instantiation. Certain linguemes occur as VARIANTS of each other, that is, alternative structures used for a particular structural element, such as alternative phonetic realizations of a phoneme, alternative words for the same meaning, or alternative constructions used to express a complex semantic structure such as comparison. The locus for a set of variants is essentially the VARIABLE in the sociolinguistic sense of that term, that is, ‘two ways of saying the “same thing”’ (Weinreich, Labov & Herzog 1968:162; see §3.3.1, §6.2). Only one variant can

⁹ We may remain fairly neutral as to what sort of mental representations of linguistic structures and their relationships is required by the ability to replicate linguemes; all that matters is the ability to replicate linguemes. For more specific proposals for mental representations conforming with the evolutionary framework, see §2.4.3, §8.1, chapter 9 and Croft (2001, in prep.).

occur in the appropriate structural position in an utterance. All the variant linguemes at all positions in the structure of utterances are part of the lingueme pool. This phenomenon resembles the phenomenon of alleles, the alternative forms of a gene that can occur at a single locus on a chromosome, in gene-oriented theories of biological evolution. This parallelism is probably not an accident.

I will call this theory of selection in language change the THEORY OF UTTERANCE SELECTION for language change. I conclude this section with three important observations about the claims made by the Theory of Utterance Selection.

First, the Theory of Utterance Selection does not preclude the existence of selection processes in language change at other levels of the language, the individual and society. The Theory of Utterance Selection does however assume that utterance selection, in which the lingueme is the replicator and the speaker is the interactor, is the primary locus of language change, and hence that most language changes can be accounted for in terms of utterance selection. Selection processes at other levels of organization will be discussed in appropriate places in this book (see §3.2, §8.6).

Second, the hypothesis that utterance selection occurs does not entail a particular set of causal mechanisms for replication or selection of linguemes in utterances. Of course, a proper utterance selection theory of language change will propose certain causal mechanisms for replication and selection, and attempt to account for observed facts of language change with those mechanisms. Most of chapters 5–7 will be devoted to presenting the case for those mechanisms.

Third, the Theory of Utterance Selection for language change puts linguistic convention at center stage (see §1.3). Normal (i.e. identical) replication of linguemes in utterances is conforming to the linguistic conventions of the speech community. Variation in replication of linguemes in utterances – the creation of linguistic variants – is a causal consequence of not conforming to the linguistic conventions of the speech community. The reasons for nonconformity are the causal mechanisms of variation in replication. And the selection of linguemes is equivalent to the establishment of a linguistic convention in a speech community. The factors in selection of a lingueme are the causal mechanisms of selection.

2.6 Language structure in an evolutionary framework

In the Theory of Utterance Selection, there does not appear to be anything like the traditional structures of linguistic analysis. There are a large number of linguemes that occur in utterances and form lineages (see §2.6.4). This may sound like a return to the prestructuralist view held by many 19th century dialectologists, that every word has its history, and the words do not form a system of structures. This view was attacked by structuralist linguistics, who argued that the linguistic system functions as a whole. However, both the 19th-century view and the structuralist view have an element of truth in them (§8.1, chapter 9). Lineages of different kinds of linguemes can be remarkably independent of each other. Yet they must all interact in order to form utterances, and that interaction implies the existence of a system. The linguistic system is one of coevolving linguemes; its structure emerges from their coevolution.

The production of an utterance involves replication of phonemes, morphemes, words and syntactic constructions (and their semantic content). But utterances are themselves very complex, and the production of an utterance implies a complex organization of the grammar (= speaker knowledge). Replication of those various linguemes must be coordinated carefully in order to produce an acceptable utterance, i.e. one that is positively selected by speakers (linguistic interactors). In particular, replication of a syntactic construction requires replication of its

component lexical items; replication of lexical items requires replication of their component morphemes; and replication of morphemes requires replication of their component phonemes.

It should not come as news to linguists that phonology, morphology, lexicon and syntax are distinct levels in a hierarchy of greater inclusiveness. Indeed, these facts about lineages in linguistic evolution reveal that this basic structure of grammatical organization appears to hold in the evolutionary model of language change advocated here.¹⁰ But in biology a simplistic view of the structure of the genome, popularly called ‘beads on a string’, in which genes correspond to bits of DNA on a chromosome, is universally accepted as false: ‘If ever anyone thought that genes are like beads on a string, recent advances in molecular biology have laid that metaphor to rest’ (Hull 1988:218; see also Hull 1988:442; Mayr 1982:794–807; Dawkins 1982b:85–6; Griffiths and Stotz 2006). Hull argues that the same conclusion follows for conceptual evolution: ‘There are no unit genes or unit ideas’ (Hull 1988:449).

Even the notion of genes or concepts as a hierarchical organization of beads on a string is inadequate. Although Hull argues that ‘in both biological and conceptual evolution, replicators exist in nested systems of increasingly more inclusive units’ (Hull 1988:449), he also writes, ‘Yes, conceptual evolution can occur at a variety of levels, and, no, the levels are not sharply distinguishable. But by now it should be clear that exactly the same state of affairs exists in biological systems’ (Hull 1988:424). The status of an entity as a replicator is determined by the evolutionary processes that influence it:

As in the case of Williams’s (1966) definition of a evolutionary gene and Dawkins’s (1976) parallel definition of a replicator, the ‘size’ of a conceptual replicator is determined by the selection processes in which it is functioning. From the point of view of replication alone, units are not needed. Entities can pass on their structure largely intact even if this structure is not subdivided into smaller units. (Hull 1988:443)

Language is no different from genes or concepts in this respect. Yet the great majority of theories of language structure are based on a beads-on-a-string model, or more commonly a hierarchy-of-beads-on-a-string model, also called the building-block model (Langacker 1987:452). Segmental phonology represents sound structure as beads on a string (phonemes), while metrical and prosodic phonology adds a hierarchy of inclusive metrical or prosodic units to the phonemic string. Most syntactic theories are based on phrase structure, that is, a hierarchical organization of a string of words. Many theories of morphology treat morphemes (minimal meaningful units) within words as beads on a string, sometimes hierarchically organized.

Of course, such theories must confront the empirical reality that language is not best described as a hierarchical organization of beads on a string. These theories are differentiated by the theoretical constructs devised to handle these facts: movement (transformations) in generative grammar, features and their matching or unification in nontransformational syntactic theories and

¹⁰ Construction grammarians may object to the syntax/lexicon distinction I am making here. Langacker (1987) argues for a syntax–lexicon continuum. However, I am casting the syntax/lexicon distinction in this passage as the distinction between a complex whole and its component parts. When Langacker and other construction grammarians argue for a syntax–lexicon continuum, they are arguing that syntactic knowledge should be represented as constructions which consist of pairings of syntactic form and semantic-discourse function, and which can occur at varying degrees of schematicity (e.g. [*VERB OBJECT*] and [*kick [the bucket]*]). In this view, lexical items are merely simplex, maximally specific constructions; but constructions are organized in a network like the lexicon. The construction grammar model of grammatical knowledge as complex form–meaning pairings in fact fits well with the philosophical definition of linguistic convention described in §4.2.4.

some theories of morphology; distinct tiers (which are also represented as hierarchical beads on a string) that are linked together in autosegmental phonology and autolexical syntax; multiple levels in level-ordered phonology and morphology and in syntax. Very few theories of language structure do not take the hierarchical beads on a string model as the starting point for structural analysis. These latter theories include varieties of construction grammar that originate in Fillmore, Kay and O'Connor (1988), including Goldberg's theory (1995, 2006) and Radical Construction Grammar (Croft 2001, 2013, in prep.); Bybee's model of morphology (Bybee 1985, 2001, 2007, 2010) and to some extent earlier word-and-paradigm models of morphology; and articulatory phonology (Browman and Goldstein 1989, 1992) and the templatic phonology proposed in Vihman and Croft (2007).

In the rest of this section, I will survey some of the ways in which language structure does not fit the hierarchical-beads-on-a-string model. In §2.6.1, the interdependence of levels of inclusiveness will be described. The building-block model of linguistic organization I have suggested implies that the higher (more inclusive) levels of linguemes do not specify any information occurring at lower (less inclusive) levels in the structure that they replicate. But in fact they often – perhaps usually – do. In §2.6.2, I discuss some striking parallelisms between the complexity of genes and of linguistic structures, which also undermine the hierarchical-beads-on-a-string model. In §2.6.3 I discuss coevolution and linkages between linguistic units in language change. In §2.6.4, I discuss linguistic categories in their temporal dimension, a dimension that is rarely addressed in analyses of linguistic structure.

2.6.1 The nonindependence of levels of inclusiveness (hierarchical structure) of linguemes

There are examples of the nonindependence of levels for all of the inclusive levels described above: phonemes, morphemes, words and constructions. We begin with examples of interdependence between morphemes and phonemes. Old English had a phonological process by which intervocalic fricatives were voiced; voiced fricatives were not separate phonemes, but allophones of the voiceless fricatives between voiced segments (Hogg 1992:92). The voicing distinction in fricatives became phonologized as a result of the loss of the gemination distinction between [s:]/[z], [f:]/[v], etc. (Lass 1992:59–60), and so the *f/v* alternation was no longer allophonic. That is, instead of [f] and [v], etc. being variants of a single lingueme, the lineage split into two. Yet the *f/v* alternation was retained for example in *life/lives*, *knife/knives*, *wife/wives*, etc. after the loss of the allophonic rule in general. What has happened here is that the plural form of these nouns has been identically replicated at the lexical level even though the replication of intervocalic fricatives at the phonological level was altered (and also the conditioning environment was lost with the loss of the following vowel). These examples demonstrate that these lexical items, in particular the plural word forms, have a degree of integrity in replication that prevented the loss of the allophonic alternation when the phonological system of English changed. In other words, lexical replication can be almost completely independent of phonological replication, to the point of specifying phonological patterns independent of the lineages of the individual phonemes in the word.

Of course, for those speakers who say *roofs* rather than *rooves*, altered replication of the phoneme in this lexical item has led to altered replication of this particular lexical item (due to paradigm leveling; see §6.2.1). This example demonstrates the unremarkable fact that phonological replication can be independent of lexical replication, to the point of specifying the

phonological content of lexical items. This fact is unremarkable because it follows from most linguists' reductionist structuralist assumptions that the properties specified by the lower levels of linguistic organization completely determine those properties at higher levels of organization.

The more remarkable examples of *life/lives*, etc. demonstrate that higher levels sometimes specify information at lower levels. This fact shows that linguemes are not organized as beads on a string, or as building blocks, easily dividable into units. If the proper representation of *lives* required it to be subdivided into smaller units, then it would be pronounced *lifēs*, at the time that the phonological rule was lost or afterwards. (The instantiation of the voiced allophone of the Old English /f/ phoneme is now presumably merged with the lineage for /v/ independent of /f/.) Instead, at least at the time of the loss of the voicing alternation, the word *lives* was a single unit lingueme including specification of the voicing of the fricative as well as its grammatical and semantic properties.

The same sort of phenomenon demonstrates that morphological patterns are independent of phonology. This can be shown by phonological alternations affecting only specific morphological forms. An example of this is the phonological alternation between [s], [z] and [ɪz] found in the English plural suffix (*books, rods, boxes*) and also in the 3rd person singular present suffix (*looks, flies, misses*). The widespread existence of so-called morphophonological rules (phonological patterns that are restricted to specific morphological or lexical classes) demonstrates that lexical items and morphemes quite frequently specify phonological properties as part of the structure that they replicate, rather than leaving it to the phonological level to specify.

Linguists have generally accepted the existence of morphophonological rules, although in fact the analysis of morphophonological rules has always called for extra theoretical constructs of dubious value (abstract underlying segments in generative phonology, multiple-level lexicons in lexical phonology, and so on). The most neutral representation of this sort of cross-level specification in structural linguistic analyses is to describe a phonological rule as referring to a morphological class or a morphological boundary. We may call this analysis UPWARD SPECIFICATION: the phenomenon is described at the lowest level (in this case a phonological process), but the rule in addition specifies properties of higher levels (morphological class). The representation entailed by the description of linguemes in the evolutionary framework is DOWNWARD SPECIFICATION: a morpheme or class of morphemes specifies some of its phonological properties. Downward specification is the proper description of the locus of replication of the properties of the lingueme because the lingueme is an entity existing at the higher, more inclusive, level. Downward specification is essential for syntactic representations as well (Croft 2001; see below). Downward specification is an example of emergentist behavior of complex entities, in contrast to the reductionist building-block model, where larger units are defined in terms of smaller units. Unsurprisingly, emergentist analyses of biological phenomena have also been proposed (Sterelny and Griffiths 1999:137-48; El-Hani and Emmeche 2000).

Examples of downward specification can be found in the interactions of other levels in language structure. There are cases where particular syntactic constructions possess special phonological patterns unique to them. English possesses phonologically special contracted forms of the English auxiliaries and *not* as in *I'm going* and *He won't go*. These contractions are not manifestations of general (i.e. exceptionless) phonological patterns. Moreover, they can only be described at a syntactic level, since they violate the phonological integrity of individual words and also violate syntactic boundaries such as that between subject noun phrase and predicate phrase in *I'm going*. Less dramatic but far more common examples of phonological properties

specified by syntactic constructions are sandhi phenomena and more generally, any phonological processes that cross word boundaries. These examples demonstrate that syntactic constructions are replicators which may specify phonological structure as well, rather than simply inheriting the phonological properties from lower levels of organization.

Lexical items can function as units specifying morphological properties rather than simply being built up from morphemes. For example, alongside the plural *brothers*, which involves the independent replication of the stem and the plural suffix, there also exists *brethren*, in which the lexical item has survived with an otherwise relic plural (cf. *children*) and also was replicated with a specialization to one meaning of *brother* (see §7.3). Another example is *shadow*, which formerly was an oblique case form of *shade*, but has been independently replicated from *shade*, with a distinct meaning and no specialized case function (*Oxford English Dictionary*). A more complex example is *hole/hollow* [n.], which may have resulted from a split of alternative inflectional forms of the Old English noun *holh* ‘hollow’ (ibid.). Less dramatic but far more widespread examples are the sorts of semantic variation found in the meaning of derivational affixes: compare the meaning of the *-er* suffix in *runner* (a person who runs on a regular basis), *walker* (the object used by people who have difficulty walking), *broiler* (a chicken that one broils), *fiver* (a five-pound note, in Britain), and so on (Ryder 1999). In these cases, the lexical item as a whole specifies the role whose referent is picked out by the *-er* derivational suffix.

Syntactic constructions can also be replicated with the specification of properties of their component lexical items independent of the replication sequence of the lexical item itself. Idioms such as *tell time* specify the meaning of the verb *tell* as ‘count’, even though the verb *tell* as a word lineage no longer occurs with that meaning. Many, in fact most, idioms are what Nunberg, Sag & Wasow (1994) call ‘idiomatically combining expressions’, where the meaning of the lexical items involved is specified as part of the structure replicated by the construction. For example, in the verb-object idiom *pull strings* ‘exploit personal connections’, *pull* means ‘exploit’ and *strings* means ‘personal connections’ in only that collocation (ibid., 496). This is not merely a phenomenon of idiomatic expressions. Radical Construction Grammar (Croft (2001, 2013, in prep.) argues that all syntactic structures involve downward specification. Most syntactic theories employ a building-block model of syntactic constructions: a construction such as the passive is built out of smaller units such as subject, verb, and passive verbal suffix. But the categories of these smaller units (the building blocks), such as subject, are defined by their occurrence in the larger constructions (intransitive, transitive, passive, etc.). In the nonreductionist approach to syntax advocated by Radical Construction Grammar, constructions are basic units of syntactic structure; that is, they are independent linguistic replicators that specify properties of their component parts.

Finally, syntactic constructions can be replicated with the specification of properties for specific morphemes such as their semantics, position or form. English lacks much morphology, but one example of a morpheme whose meaning is specified in the construction is the passive participle affix represented as *-en* in the perfect construction [*SBJ have VERB-en (OBJ)*]. The passive participle morpheme in this construction does not have the passive voice meaning that it otherwise has (as in *the boys were taken home; the window is broken; a word borrowed from Italian*). Its perfect meaning in combination with the auxiliary *have* is specified by the construction and is a result of the independent replication of this construction, including its morphological affixes, from the morphological units that appear to make it up. Again, this fact can be accommodated by treating syntactic constructions such as the perfect construction as independent replicators.

An evolutionary theory of language does not discard the notion of linguistic structure with interlocking linguistic units. Linguemes occur at different levels of inclusiveness. This provides much of the linguistic structure of utterances, namely its hierarchical structure to the extent that such structure exists. However, more inclusive linguemes as replicators often specify the structure of less inclusive linguemes that they contain. This fact demonstrates that the distinctions between these allegedly hierarchical levels are not always clear. We find evidence for this fact any time we observe the reduction from an independent word to a bound morpheme, the fusion of two morphemes, the morphologization of an exceptionless phonological rule, or the semantic specialization of words in idioms or morphemes in particular words and constructions.

This fact has also occasionally been used to argue against the independence of these linguistic levels. But this fact does not invalidate the independence of these levels in replication in many other cases, that is, where phonological, morphological, lexical, syntactic and semantic changes occur in a wide range of utterance contexts. There is no incompatibility in the hierarchical organization of phonology, morphology, lexicon and syntax, and recognizing that linguemes can specify replicable structure at multiple levels in the hierarchy. Of course, a theory of grammatical representation must allow for this possibility, preferably as transparently as possible; this is one of the goals of Radical Construction Grammar. And the relationship between units at the same level of inclusiveness is not one of hierarchical beads on a string, as will be described in the next section.

2.6.2 Functional linguemes and their relationship to utterance form

In §2.3.3, we discussed some of the problems in defining the relationship between “genes” and their putative physical manifestation. Griffiths and Stotz (2006) focus only on the role of genes in producing proteins (the facts are even more complicated regarding the role of genes for larger-scale structures and behaviors of organisms). They conclude that there are three useful concepts that go under the name of “gene”. The first is the instrumental gene, sometimes called the functional gene or evolutionary gene. The instrumental gene is a unit of evolutionary significance in its contribution to the phenotype of an organism, and its role in selection processes. The second they call the nominal molecular gene, which they describe as a practical unit, a DNA sequence, that is referred to in molecular genetics and has a practical use to ‘segment the DNA sequence into fairly traditional looking genes’ (Griffiths and Stotz 2006:515). Finally, they advocate the postgenomic molecular gene, which recognizes the true complexity of the relationship between the evolutionarily significant unit (in their narrow remit, just the proteins produced in a cell) and the molecular reality of how those units are produced.

In language, the instrumental or functional lingueme is the linguistically meaningful unit that analysts of linguistic structure—syntacticians, morphologists and phonologists—work with. In syntax and morphology, the functional lingueme is characterized as a conceptual unit, usually associated with a component of meaning. In phonology, the functional lingueme is a phoneme, also a conceptual unit, though without semantic content. But the relationship between these functional linguemes and the physical form of an utterance is as complex, and indeed complex in analogous ways, as the relationship between the instrumental gene and the postgenomic molecular gene. In this section, some of this complexity is briefly surveyed (apart from the types of examples in §2.6.1); arguments supporting the analyses presented here can be found in the works cited here.

displays internal changes to roots, such as *woman/women* for plurality. Other languages use tone patterns as morphemes, such as Chalcatongo Mixtec derivation of adjectives from nouns using a high-high tone sequence, e.g. *žuiù* ‘rock’ vs. *žúú* ‘dirty’. Finally, many languages employ reduplication, which involves the repetition of part or all of the root morpheme to express a meaning, such as Mangap-Mbula *kuk* ‘bark’ vs. *kuk-uk* ‘be barking’ and *kel* ‘dig’ vs. *kel-el* ‘be digging’.

Various morphological theories have devised different means for representing nonconcatenative patterns, but most treat them as a deviation from the building block model. Bybee’s theory of morphology takes the opposite approach (Bybee 1985, 2001, 2007, 2010). She treats words as pairings of form and meaning that are related to one another in a network structure. Morphological patterns consist of correspondences between phonological units in related word forms, and between semantic components in related word meanings. Concatenative morphology emerges as a special case (albeit the most common one) in which a correspondence of semantic equivalence is correlated with a systematic correspondence of a sequence of phonological units—that is, a phonological sequence with a consistent meaning.

Phonology involves the analysis of the sound structure of words and utterances. As with syntax and morphology, the basic phonological unit is assumed to be a sound segment (a phoneme), and a word is made up of segments like beads on a string. Metrical and prosodic structure adds a hierarchical organization of the beads on a string. However, the phonetic realization of phonemes (the functional linguemes of phonology) is not at all like beads on a string. Phonemes are realized on the one hand as articulatory gestures by the speaker and on the other hand as an acoustic signal that is perceived by the listener. Neither the articulatory gestures nor the acoustic signal can be divided into discrete temporal segments corresponding to phonemes. There is extensive coarticulation such that some consonantal gestures extend into neighboring vowels (and beyond), and vice versa. The actual phonetic realization of a sequence of phonemes (i.e. functional linguemes) involves coordinated articulatory gestures over continuous time. For the listener, the identification of a sequence of phonemes requires disentangling the temporally overlapping cues in the acoustic signal and relating the cues to the articulatory routine that produces those cues in the signal. The interactions of these gestures/acoustic cues give rise to varied phonetic realizations of individual phonemes in part due to the context of neighboring phonemes in a word or utterance.

Most phonological theories retain the building block model of a hierarchical sequence of discrete units, although autosegmental and metrical phonology allows for some overlap by having phonological features spread across sequential units. Articulatory phonology, however, abandons the beads on a string representation (Browman and Goldstein 1989, 1992, 1995, 2000). In articulatory phonology, the basic units are gestures—actions—produced by sets of articulators that result in constrictions of the vocal tract. These gestures vary in magnitude and duration, and therefore overlap temporally to greater or lesser degrees. The gestures are temporally coordinated to each other to varying degrees of strength (Browman and Goldstein 2000), but there is enough flexibility in timing that variation due to speech rate and other factors lead to the effects traditionally described as phonological processes. Certain patterns of coordination of gestures give rise to the units traditionally described as segments and syllables, but the latter are a special case (albeit the most common one) of the range of gestural coordination patterns.

The domain of articulatory gestures and their coordination is the word, which is also the basic unit of phonological analysis in Bybee’s model (Bybee 2001) and in Ohala’s acoustically-based model of sound structure (Ohala 2003). Vihman (1996, Vihman and Croft 2007) argues that

phonological acquisition is organized by phonological templates, that is, a set of temporally coordinated articulatory gestures for an entire word. Phonological acquisition involves the gradual mastery by the child of the articulatory gestures and refinement of their temporal coordination. Vihman and Croft also argue, like Browman and Goldstein, that the phonological structures of the adult systems are organized as phonological templates of words, and that phonological categories for classes of sounds (including consonant and vowel) are defined by their position in word-level phonological templates.

All levels of language structure violate the building block model of linguistic units as a hierarchy of beads on a string. Most theories of linguistic structure still take the building block model as a starting point, but in recent decades, theories of syntax, morphology and phonology have been put forward that start from models that more closely resemble the postgenomic approach to the gene.

2.6.3 Language structure and lingueme coevolution

Sounds, words and constructions coevolve over the course of time. The results of the coevolution sometimes lead to such a tight linkage that one must consider them to have become a single lingueme, as illustrated in the examples given in §2.6.1. Even if distinct linguemes at the same or different levels of inclusiveness do not coalesce into a single lingueme, their form and meaning coevolve. For example, the replication of a sound is influenced by their neighboring sounds in utterances, and likewise with morphemes and words in constructions, particularly in their meanings. Functional linguemes—the entities that are conceived of as distinct units in linguistic analysis—are so intertwined in their physical realization in utterances (see §2.6.2) that they necessarily coevolve, just as functional genes do in a genome. These coevolutionary processes are as much a part of language structure, and their outcomes make up a large part of the phonological, morphological and syntactic rules that constitute a traditional grammatical analysis. Moreover, functional linguemes are themselves the product of mental processes employed in producing and interpreting the form of an utterance, and are interlocking and overlapping structures in the utterance itself. This is another aspect of language structure that poses problems for traditional grammatical analysis.

The concept of an instrumental gene/functional lingueme depends on its role as an independent unit in selection. Yet the concept of function and the role of adaptation in biological selection is also a problematic one. The neo-Darwinian view is that adaptation of an organism to the environment is the most significant causal mechanism for selection. Gould and Lewontin (1978) challenge this view. The critique of adaptationist views has at least two prongs. The first is that a trait currently possessed by an organism may have been adaptive for the environment that existed when it originated, but may not be now (it is vestigial); or it may even be appropriated for another adaptive function in a later environment with which the organism interacts (exaptation; Gould and Vrba, 1982). Hence adaptation must always be examined in a historical perspective (Sterelny and Griffiths, 1999:218, 224).

The second prong is that a trait may not be adaptive for the current environment because it is in fact the consequence of a complex phenotypic expression, another aspect of which is adaptive (or was adaptive). That is, traits may be interconnected in the genotype, or in development, or both (see above), and so the presence of that trait is not a direct result of interaction with the environment, past or present. As Sterelny and Griffiths point out, the problem here is determining the division of an organism into parts that are genetically and/or developmentally

independent. (They also note that Gould and Lewontin go to nearly the opposite extreme, reviving the notion of a *Bauplan* or highly integrated structure of an organism, such that most of its traits are a side-effect, so to speak; Sterelny and Griffiths, 1999:228-30). One possibility is that traits are integrated because of their interconnection in development, a process called generative entrenchment (Wimsatt and Schank 1988). All of these examples also imply a tight linkage between units to the point that they may be considered a single evolutionary unit.

Language change also displays conservatism, vestigial traits, exaptation, and nonadaptive traits that exist because they are integrated with other, possibly more adaptive ones. The adaptation of linguistic structure to its environment is the reflection of functional motivation. Yet linguistic structures are remarkably conservative. Conservatism is chiefly due to the tremendous power of convention as an effective means of communication (§4.2.4). Vestigial linguistic forms persist even when they no longer express a linguistic function: for example, the *-r-* of *children* is a vestige of a Germanic plural suffix (compare German *Kind-er* ‘children’), whose function has been appropriated by the suffix *-en* (compare *oxen*, *brethren*; other examples of vestigial linguistic traits are described in §5.4). Finally, vestigial linguistic constructions may be exapted to other functions, such as the exaptation of the English third person singular suffix *-s* (e.g. *walk-s*) to express aspectual meaning in some nonstandard English dialects (other examples are described in §5.3).

Nonadaptive traits may be found in the grammaticalization of constructions such as English *be going to* as an expression of future time reference. While it is the entire construction that undergoes grammaticalization, it can be argued that it is the motion verb *go* that has come to be associated with future meaning in the construction. To the extent that this is true, it would imply that the presence of *be*, *-ing* and *to* in the construction are not adaptive in themselves, but rather part of an integrated structure another part of which is adaptive. Some evidence that these other parts are nonadaptive, or at least not independent traits, is the fact that *to* and *-ing* have fused with *go*, leading to reduction in form, to *gonna* or even simply the schwa vowel.

2.6.4 Temporal linguistic structure: linguistic lineages

One advantage of the evolutionary framework for language is that it provides a temporal dimension for language structure as well as the synchronic dimension of the organization of linguemes in an utterance. In the evolutionary framework, a language is a population of utterances (consisting of linguemes) in a speech community, and this population exists across time as well as space. The temporally-defined structure of a language consists of lingueme lineages and their coevolution in a language.

A lineage is the spatiotemporally bounded individual resulting from replication of a lingueme. The first linguistic lineage that probably comes to the reader’s mind is a word ETYMOLOGY. A word etymology is a summary of all the replications of the word, which usually is replicated in an altered state over a long enough period of time – sound change, semantic change, syntactic change, etc. A lineage of a biological replicator can go on indefinitely, in principle at least, although the species which contains it may terminate through its splitting into daughter species. Likewise, a word etymology extends indefinitely, even though it may be traced back through different languages – Old English, Proto-Germanic, Proto-Indo-European, and further back. Likewise, the lineage can be traced forward even to a creole such as Torres Strait Creole English (see §8.5). A grossly simplified example of such a lineage is Proto-Indo-European *bhlē* ‘blow’ > Proto-Germanic *blē-w* ‘blow’ > Old English *blāwan* ‘blow’ > Middle English *blowen* ‘blow,

smoke, carry by wind, play a wind instrument, etc.’ > Modern English *blow* ‘blow, smoke, carry by wind, play a wind instrument, cause to explode, etc.’ > Torres Strait Creole *blo* ‘blow, puff, pant’ (*American Heritage Dictionary New College Edition*; *Oxford English Dictionary*; Shnukal 1988:117).

A word etymology is probably the prototypical case of a linguistic lineage; but sounds and grammatical constructions form lineages as well. The phoneme /f/ is a lingueme that has been replicated in utterances millions of times over in the history of English and even further in the past (cf. Heringer 1988, cited in Keller 1990/1994:158–59; Ritt 1995). This replication can be differential: /f/ can change from [f] to [h] for instance. Historical linguists notate this change as *f* > *h*; what this means is that there is a lineage of replications of a sound in which altered replication has occurred. Hence a SOUND CHANGE, as historical linguists call it, can be reformulated as a sound lineage. Of course, persistence or survival of a sound is a lineage as well.

A type of lineage that has become of great interest in recent historical linguistics and diachronic typology are the lineages that result from grammaticalization of a construction, called GRAMMATICALIZATION CHAINS (Heine, Claudi & Hünnemeyer 1991:221–2; Heine 1992). Grammaticalization chains are actually lineages for whole syntactic constructions, not just individual lexemes or morphemes (Bybee, Perkins & Pagliuca 1994:11; Traugott 2000). For example, the construction [*X is going to VERB*] has been replicated millions of times in the history of English. The replication has been altered over time in that, semantically, it has changed from motion + purpose to future meaning, and, phonologically, it has changed from ... *going to* ... to ... *gonna* ... Nevertheless, it still represents a single lineage replicated by many different speakers on many more different occasions of use over several centuries.

These linguistic lineages represent a temporal perspective on lingueme populations. Linguemes are tokens of linguistic structure in utterances, that is, usage events. The usage-based or exemplar approach to language structures takes a more-or-less synchronic perspective on lingueme populations. The usage-based model is found in exemplar-based approaches to phonology (Pierrehumbert 2003, 2006; Bybee 2001), polysemy analyses of lexical and constructional meaning (the seminal works being Lindner 1982; Brugman 1983; Lakoff 1987; see also Croft and Cruse 2004, chapter 4), and usage-based approaches to morphology and syntax (Bybee 1985, 2007; Langacker 1987, 2000; Croft in prep.). In all of these approaches, linguistic categories in a speaker’s mind—phonemes, word and morpheme meanings, and constructions as categories of sentence types—are represented as a set of exemplars derived from usage events, which are organized into a network by similarity relationships between the uses. In the more recent exemplar models, the uses are directly derived from actual usage events. The mental categories of a speaker therefore change over the speaker’s lifetime based on her exposure to instances of those categories in usage events.

These mental categories are of course a property of the interactor in language change, not the replicator (the lingueme). Lingueme populations exist between speakers and extend beyond individual speakers, including those speaker’s lifetimes. But in usage-based/exemplar models, there is a very close relationship between the lingueme population and the mental knowledge of the interactor that replicates individuals in the lingueme population, unlike traditional models of linguistic categories. Traditional models, those based on classical necessary-and-sufficient-condition definitions of categories, tend towards an essentialist, ahistorical representation of linguistic categories. It cannot be denied that speakers form generalizations about conceptual categories. But usage-based/exemplar models indicate that mental categories of language units

are better analyzed as populations held together by conceptual similarity, which may evolve over the speaker's lifetime. A speaker's knowledge about her language, and thus her means of replicating utterances, is sensitive to past usage events and hence differs from speaker to speaker within the same speech community. Thanks to the feedback from the utterances that a speaker produces and is exposed to over her lifetime, it undergoes changes even in her lifetime. After all, it is a speaker that gives language its temporal dimension by her choices of linguemes to replicate in the utterances she produces over time.

2.6.5 Summary: structuralist, generative and evolutionary theories of language and its structure

The theory of language structure outlined here is very different from the structuralist and generative theories of the past century. Structuralist and generative theories tend towards an essentialist theory of a language, its structures and its categories. Generative theory has shifted attention away from language as utterances to an idealized, essentialist model of a speaker's knowledge which is basically ahistorical (and even "genetically determined"), even though it is claimed to be a property of living human beings. The evolutionary model here is not essentialist but population-based. Populations are historical entities, spatiotemporally bounded sets of actually existing entities. The basic linguistic population is the speech community, defined in terms of actual (and hence relative) communicative isolation. The speech community produces utterances over the time of its existence—this is its language, in all of its variability. The utterances are recombinations of replicated tokens of linguistic structures (linguemes). These are the replicators in language change. A grammar is the actual linguistic knowledge of individual speakers that they use in producing utterances and replicating linguemes. The grammar is part of a complex adaptive system: it forms a feedback loop with language use, both creating utterances and being altered by those utterances. Speakers are the interactors in language change, who replicate linguemes in utterances and thereby extend and maintain the population of utterances. In the evolutionary framework, a language and its structure has temporal extent as well (compare the panchronic approach of Heine, Claudi and Hünemeyer 1991, chapter 9). Even for individual speakers, language has a temporal extent.

The linguistic structure of utterances in the evolutionary framework is also very different from structuralist and generative theories of language structure. The latter theories start from a view of language structure as a hierarchical organization of beads on a string (the building block model). Language structure, like the structure of the genome, does not fit this model. Structuralist and generative theories of language derive much of their complexity in representation from attempts to patch the hierarchical-beads-on-a-string model. The relationship between linguemes—the functional units of syntax, morphology and phonology—and the form of an utterance is quite complex. The facts of language structure require not just deviations from the building block model, but a reconceptualization of language structure. Only relatively recently have theories of language structure been proposed that do not take the building block model as a starting point. All of these recent theories have certain traits in common: more inclusive structures function as single units (e.g. constructions, words); these larger structures can be discontinuous and overlapping; the larger structures define categories and specify structures at "lower" levels of organization; and the interpretation and identification of the linguemes or functional units involve much more than the utterance form, in particular mental processes and knowledge of the speaker and the hearer. In all of these respects, the analysis of language structures into linguemes

is no different from the postgenomic notion of the gene in biology. Language categories are also historical entities, lineages of their use in the speech community. Even linguistic categories in a speaker's mind are populations of exemplars that evolve as part of the feedback loop with the categories of linguemes in utterances. A number of recent theories of syntax, morphology and phonology, most notably the usage-based model, take this view of language structure. The evolutionary framework provides a foundation for these theories of language.