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The Two-Stage Life Cycle of Cultural Replicators

1. Introduction

Linguistics is the study of two separate but related phenomena, human languages and our unique ability to speak them. This unique ability, often referred to as the *Language Faculty* (LF), is a biologically determined adaptation that is essentially universal among humans. We do not know the exact sequence of historic stages this faculty went through during its evolution, or exactly what selection pressures it evolved in response to, and it has been argued that due to a lack of data, we never will (Fitch *et al.* 2005). But thanks to work in molecular biology over the last 150 years, we now have a fairly good understanding of the genetic mechanisms underlying its evolution, and are beginning to identify gene sequences and pathways directly related to it (Lai *et al.* 2001; Dediu & Ladd 2007).

The biological evolution of the LF is however not the only evolutionary process that is linguistically important. The actual languages we speak can also be shown to be products of evolution, albeit evolution of a very different kind (Croft 2008). Instead of resulting from biological evolution based on the differential replication of DNA sequences, languages are products of an evolutionary process based on the differential transmission of linguistic information between individuals. They are products of cultural evolution, which is currently far less well understood than its biological counterpart. Both evolutionary processes do share many similarities; both depend on some form of heredity, variation and differential selection and are in Dennett's (1995) terminology two instances of the "substrate neutral" Darwinian algorithm. But the mechanisms underlying the two are vastly different, and while genetic theory has explained many of the biological mechanisms, no equivalent cultural theory exists. Such a theory is needed before Darwinian thinking can be rigorously applied to the study of cultural change in general, and language change in particular.

The possible foundations for such a theory can be found in Dawkins' (1976) concept of a *meme*. Unfortunately researchers seeking to develop this idea further have been unable to agree on just how memes should be defined, and dispute the importance of a number of key concepts such as *meme phenotype*. These disagreements have resulted in significant confusion and a number of divergent and largely incompatible theories of memetic cultural evolution. This paper attempts to resolve some of the confusion surrounding the definition of memes by providing a new characterization of them in terms of a novel two-stage lifecycle model. This approach circumvents much of the existing disagreement and introduces a new way of conceptualizing memes, which is demonstrated to be useful for capturing several distinctions that had previously proved problematic.

It is hoped that the two-stage life cycle model will contribute to the development of a uniquely cultural theory of Darwinian evolution. Such a theory would have obvious benefits not only to the study of language change, but also for the study of cultural change more generally. The examples presented in this paper are primarily linguistic in nature, but it is expected analogous examples can be found in nearly any field of cultural study. The model presented here does not depend on any specific characteristics of language change and so it too should be easily generalized to application in other fields.

The linguistic implications of a cultural theory of evolution extend beyond just the study of language change and also impact the study of the LF. This is due to the interaction of biological and cultural evolutionary processes during LF evolution. The culturally evolved languages present in the LF's environment contributed to determining the selective pressures acting on it throughout its evolution. The varying states of the LF in turn helped determine the cultural selection pressures acting on language evolution. Together languages and the LF can be seen as forming a single co-evolutionary system (Durham 1992), the full understanding of which depends on an understanding of both the cultural and biological components. Thus a better understanding of cultural evolution can potentially benefit even those studying purely biological aspects of linguistics.

The paper is structured as follows. Section 2 discusses the varying definitions of memes in the literature and identifies some of the main points of contention. Section 3 gives background on the life cycles of biological replicators, and defines the meanings of important biological terminology. Section 4 considers the relevance of a biological style phenotype/genotype distinction to memes. Section 5 builds on the discussion of this distinction and introduces a life cycle model more appropriate to cultural replicators.

Sections 6 and 7 demonstrate the utility of this life cycle model by analyzing incremental meme copying and meme reactivation. Section 8 extends the life cycle model to naturally handle Blackmore's (1999) copy-the-product versus copy-the-instructions distinction and argues that it demonstrates the important concept of meme specialization. The final section identifies advantages of the life cycle model and suggests directions for future work.

2. Ambiguous Meme Definitions

This section looks at the different definitions of *memes* given by various authors and highlights some of the main points of difference between them. A common misconception regarding the discrete nature of memes is briefly addressed, and disagreement concerning the relevance of "meme phenotype" is outlined.

Much of the ambiguity surrounding memes stems from their original introduction by Dawkins (1976: 189). He introduced them primarily to illustrate the replicator centric theory of biological evolution he was arguing for at the time, and did not intend them to form the basis of a theory of cultural evolution (1999: xvi). Given his aims, the lack of a rigorous definition is understandable, but it is directly to blame for much of the uncertainty as to what should be considered a meme since then (Rose 1998).

Dawkins' initial presentation of memes was not in the form of a definition at all, but rather by way of an analogy with genes and a list of proposed examples. Following a brief discussion of cultural transmission, and the potential for "the soup of human culture" to support a replicator analogous to a biological gene, Dawkins proposed that such cultural replicators should be called "memes". He then made the following comments:

> Examples of memes are tunes, ideas, catch-phrases, clothes fashions, ways of making pots or of building arches. Just as genes propagate themselves in the gene pool by leaping from body to body via sperm or eggs, so memes propagate themselves by leaping from brain to brain via a process which, in the broad sense, can be called imitation. (Dawkins 1976: 192)

Neither the examples given nor anything else in *The Selfish Gene* makes it clear whether Dawkins intended for memes to be considered as the physical manifestation of these cultural replicators in the environment, the knowledge of them in human minds, or some combination of the two. This has proved to be a common source of disagreement between authors wishing to build theories of cultural selection based on memes, and will be one of the issues addressed in this paper. As for Dawkins himself, he later commented on his oversight and suggested that memes should be considered as being cultural knowledge in the brain (1982: 109), similar to Cloak's (1975) i-culture instructions.

Despite Dawkins' later clarification of the location of the entity he intended the term meme to refer to, other authors have taken a range of positions on this issue. The most common position is in agreement with Dawkins' clarification and places memes inside the brain (Dawkins 1982, Delius 1989, Ritt 1996, 2004, Brodie 1996). This brain-internal position appears to benefit from the perception that brain-located memes are potentially more active than artifacts located in the environment due to their greater ability to directly influence the behaviors of their hosts. Another significant group of authors have advocated the opposite position, and argue for a view of memes as being entities primarily located in the environment (Csikszentmihalyi 1993, Croft 2000). The main argument in support of this position is the observable nature of brain-external memes, which gives a more empirical foundation to the study of memes.

A third camp takes an intermediary position; they see memes as being a combination of entities located inside and outside the brain (Blackmore 1999, Dennett 1991, 1995, Durham 1992). This group acknowledges the importance of both internal and external components, but usually fails to give definite explanations of the interactions between components at these two locations. Without explaining these interactions it is difficult for proponents of this position to talk about memes in anything but the most general terms, which regularly results in difficulty discussing micro-level meme replication and selection.

Each of the three positions has advantages that are impossible to do justice to in such a short introduction. While I personally find the third position the most attractive as a kind of compromise solution, I find the current undefined nature of the interactions between the internal and external meme components to be a fatal weakness of current definitions of this kind. If this weakness cannot be overcome, or if some other acceptable compromise solution cannot be found, the current ambiguous definition of the term meme can only lead to confusion on the part of those using the term, and further fragment the fledgling field of memetic studies of cultural evolution.

Ambiguity surrounding the location of memes is not the only point of confusion stemming from Dawkins' original definition of memes. Another less common problem can be linked to his analogy with the term "gene" which itself is ambiguous. Several authors, particularly those from a social science background, seem to think that this analogy implies that memes must correspond to discrete units; "bits of culture" in Blooch's (2000) words. This seems to be as a result of the popular conceptualization of genes as discrete sections of a DNA strand, familiar from the similar usage of "gene" in molecular biology. It is however important to remember the context in which Dawkins used the term, at the end of a book on *evolutionary* biology, a field where "gene" often has a very different meaning.

The definition that Dawkins was using was one inspired by Williams (1966), for whom "A gene could be defined as any heredity information for which there is a favorable or unfavorable selection bias equal to several or many times its rate of endogenous change". Dawkins describes his own version of this definition as "not at all a rigid or all-or-nothing definition, but a kind of fading-out definition, like the definition of 'big' or 'old'" (1976: 32). These definitions hardly seem to imply the existence of discrete genes (which in any case are not necessary for replication (Hull 1988: 443)), and rather seem to propose using "gene" as a mere label for packets of genetic information of a convenient size. Dawkins (1976: 175) specifically makes use of this same "verbal trick" in his explanation of memes as he used in his definition of memes, so it is clear he intended the style of fading-out definition to carry over to memes. It is this, somewhat indistinct, not-to-big, not-to-small, interpretation of memes that is intended throughout this paper.

The final point of confusion that will be addressed in this paper concerns the relevance of the concept of phenotype to memes (Rose 1998). Varying uses of the term "meme phenotype" have been made in the literature, and its meaning is consequently ambiguous (Dawkins 1982, Dennett 1995, Ritt 1996, Benzon 1996, Rose 1998). It is most often used in reference to the external effects of a meme (cf. Dennett 1995: 355), but occasionally also in references to the behaviors of individuals (cf. Ritt 1996: 37), and sometimes even refers to a meme's effects on the brain (cf. Benzon 1996). Some authors have dismissed the term altogether, claiming it has no relevance when applied to memes (Blackmore 1999). Due to the importance of the term phenotype in the biological context, and its relationship to claims of "Lamarckian" inheritance in cultural evolution, it is seen as important that the confusion concerning this term be resolved. Therefore the next section of this paper is largely devoted to a discussion of the biological meaning of "phenotype", and section 4 discusses the application of the term in relation to memes.

Questions concerning the location of memes, and whether they have phenotypes, are not the only points of contention concerning memes. They are however amongst the most important. There also exists disagreement over what degree of importance imitation plays in their definition and whether a replicator/interactor distinction can be made (Hull 1988, Lass

1996). This paper avoids these, and other questions, and focuses on the issues surrounding meme location and meme phenotype. It is believed that if consensus is reached regarding these other issues, the results will be as applicable to the model presented in this paper as to other existing models.

3. Biological Replicator Life Cycle

Before considering the relevance of the concept phenotype to memes it is important to understand the meaning of the term in its original biological context. In addition to discussing biological phenotype, this section will also introduce the central dogma of molecular biology and the term germline, both of which will be used in later discussions.

The term phenotype was originally introduced by Johannsen (1911) to make a distinction with the concept of genotype. The genotype of an organism was defined in relation to the entirety of an organism's hereditable characteristics, regardless of their current expression in that individual. In contrast to this, the phenotype was defined in terms of the actual expression of characteristics in the context of effects of the particular environment of the individual. This is related to the earlier distinction between germ plasm and somatic cells that was proposed by Weismann (1892).

The genotype/phenotype distinction can be graphically depicted as in Figure 1 below. The heritable characteristics of the organism forming the genotype are passed on from generation to generation, and at each generation, in combination with environmental influences, shape the externally observable phenotype. The interaction between the genotype and phenotype is depicted as being unidirectional which represents the inability of modifications to the phenotype to be incorporated into the genotype of an organism. This is in accordance with the central dogma of molecular biology (Crick 1958, 1970) and is a consequence of the non-Lamarckian nature of biological inheritance.

The arrows in the figure represent heredity relationships between entities such that a mutation (or deliberate modification) of any entity has the potential to be propagated to all others reachable by following the arrows. Thus, if an organism's genotype is modified, not only will the phenotype of that organism be affected, but the modification will be passed on to all descendant organisms' genotypes as well, and indirectly affect their phenotypes. If however an organism's phenotype is modified, that modification will die with the organism, regardless of whether that organism has descendants or not.

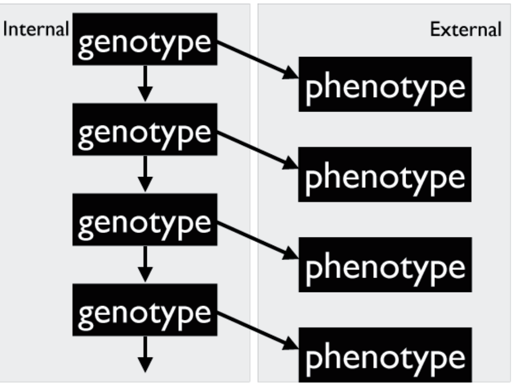

Figure 1. Biological Replicator Heredity

The difference in heritability of modifications to the genotype and phenotype can be expressed in terms of the concept of a germline. A germline is a sequence of replicating entities such that each is the direct descendant of the one before it, and that each has a potentially infinite number of its own descendants following it. A germline replicator is a member of such a sequence. Parts of an organism's genotype are germline replicators in this sense; modifications to them will be passed on to a potentially infinite sequence of future generations' genotypes. Parts of the phenotype, however, are not germline replicators. The relationships between phenotype and genotype instances depicted in Figure 1 can be generalized into relationships between phenotype and genotype types. Such a generalization is presented in Figure 2 below. The biological replicator *life cycle* is semi-cyclical in nature with phenotypes forming a dead-end off to the side. As above, the solid arrow linking the genotype to itself represents a heredity relationship. The dotted line connecting the genotype to the phenotype designates the fact that not just the genotype, but also environmental factors, are responsible for determining phenotypes. The lack of a link from the phenotype to the genotype corresponds to the inability of acquired characteristics to influence the germline genotype.

The heritable/non-heritable distinction between genotypes and phenotypes is not the only difference between the two terms. "Phenotype" also has connotations of being externally observable, of being partially determined by the environment, and of being mutable over an organism's lifetime. But in common usage these connotations remain secondary to its original meaning, and so if the term is to find usage in relation to memes, it should be in relation to its primary meaning. If its secondary meanings are intended, it will likely prove better to choose a less ambiguous term.

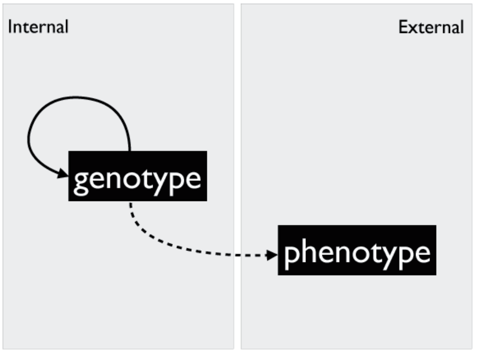

Figure 2. Biological Replicator Life Cycle

4. Meme Phenotypes

This section contrasts the life cycle of biological replicators as discussed in the previous section with that observed for cultural replicators. The interaction between internal and external incarnations of memes is of particular interest and is shown to differ significantly from that seen between genotypes and their phenotypes. The implications of this in relation to the term "meme phenotype" are discussed.

Before considering the process of meme replication it is necessary to introduce two new terms to refer to the brain internal and external manifestations of memes. Due to the current ambiguity of the terms "meme" and "meme phenotype" it is seen as best to avoid these two terms for now. It is suggested that brain-internal meme manifestations be referred to as "i-memes" and brain-external manifestations be referred to as "e-memes". These terms are reminiscent of Chomsky's (1986) "i-language" and "e-language" but this is solely due to their parallel etymology and no deeper meaning is intended by the similarity.

An alternative set of names could have been derived from Cloak's (1975) "i-culture" and "m-culture", but it seems best to avoid the connotations of "material" as something solid and tangible. Many of the memes we will be considering, particularly those of a linguistic nature, will have few lasting external physical effects and so such connotations are misleading. There do, however, exist strong similarities between the purposed i-memes and e-memes, and Cloak's i-culture and m-culture instructions.

Now, taking an i-meme as a starting point, consider the pathways whereby it can replicate itself in another brain. Short of telepathy it can't replicate directly by "leaping from brain to brain" as Dawkins whimsically suggested (1976: 192); it must take an indirect route. For example an idea you wish to convey to a friend; the most obvious way for you to transfer that idea i-meme to them is by way of an explanation. But that explanation is something physically realized in the environment as an e-meme (most likely in the form of vibrations in the air). It is from this explanation e-meme that your friend is able to reproduce the idea i-meme in his or her own brain. If we were to consider replication from the e-meme's perspective it would follow a similar pattern, but instead would require an i-meme intermediate in someone's brain to help facilitate its replication.

A depiction of the process of mediated i-meme and e-meme replication is shown in Figure 3. From the diagram it is easy to see why Blackmore calls this process of replication the memetic "zigzag" (1999: 66). I-memes create e-memes, which are then used as the exemplars for the learning of new i-memes. Neither i-memes, nor e-memes are capable of replicating themselves directly and rely on first creating an intervening meme of the opposite *phase*.

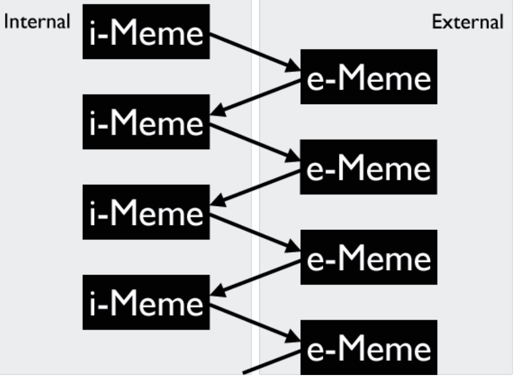

Figure 3. Cultural Replicator Heredity

Following the biological example of the previous section, consider the effects of a modification made to an i-meme. This modification has the potential to pass to the i-meme's immediate e-meme descendant. From there it may be passed in turn to the following i-meme and down a chain of i-meme to e-meme, e-meme to i-meme replications to potentially affect all of the original i-meme's e-meme and i-meme descendants. The i-meme is a germline replicator as were parts of the biological genotype.

What then happens following a modification to an e-meme? Any i-memes learnt from such a modified e-meme could, as in the previous example, be altered as a result of the change to their exemplar. A modification to an e-meme has the potential to be passed on. And not just to its immediate i-meme descendants, but also to all future e-meme and i-meme descendants. Just like i-memes, e-memes are germline replicators! This is a significant difference between e-memes and biological phenotypes.

As was mentioned in the previous section, the germline versus non-germline distinction is not the only difference between the biological genotype and phenotype, but it is the original and most salient. By showing that both i-memes and e-memes form part of a meme's overall germline, we have shown that in this important respect, neither i-memes nor e-memes can be considered as the equivalent of a meme's phenotype. Despite this, it could be decided to make use of the term anyway, perhaps in reference to the externally observable nature of both e-memes and phenotypes, but this would inevitably cause a certain degree of confusion. For this reason it is suggested that the term "meme phenotype" be disregarded as a label for either the internal or external manifestations of a meme and the labels i-meme and e-meme proposed at the beginning of this section be retained.

Having discarded the concept of meme phenotype, it is also hoped that much of the pseudo-controversy surrounding the supposedly Lamarckian inheritance of culture can be avoided. In and of itself, there is nothing wrong with the idea of evolution via acquired characteristics, it just happens that this is not the way things work in biology where there happens to be a strict one way causal flow between the germline and the phenotype as noted earlier. Cultural evolution may well be Lamarckian, but due to the demonstrated germline nature of both i-memes and e-memes, anyone wishing to pursue this idea is faced with first asking the question "characteristics acquired by what?" If the answer is either i-memes or e-memes, character acquisition is simply a form of germline mutation and not something in dire need of explanation.

There remains the possibility that the term "meme phenotype" could be used in a way other than as a label for e-memes or i-memes. For example both e-memes and i-memes could be split into both an encoded germline informational component and an outwardly observable phenotypical component. This paper suggests no particular reason for making such a distinction, but it is important to specify what the above argument did not rule out. However, given the confusion the term "phenotype" has already caused in memetics, even if such a distinction were considered desirable, the introduction of a fresh term would likely be preferable.

Much of the argument in this section was inspired by a similar argument in Dawkins (1982: 98), where he was arguing a quite different point concerning the nature of replicators. By showing that not only i-memes, but also e-memes form part of the meme's germline, we have shown that they can both be considered as replicators in the biological sense. The implication of this is that *both* the brain internal and brain external views of memes as outlined in section 2 are correct to a certain degree. The next section will demonstrate that the two views are not mutually exclusive.

5. Cultural Replicator Life Cycle

In this section we build on the discussion of meme replication and present a cultural replicator life cycle model analogous to that presented for biological replicators in section 2, but one that accounts for the differences exposed in the previous section. The model forms the basis of our characterization of a meme as a two-stage replicator. The model is briefly discussed and some of its benefits over previous models are argued for.

The previous section introduced the terms i-meme and e-meme to label respectively the internal and external manifestations of a meme. It further showed that both i-memes and e-memes are both germline replicators that depend on each other to mediate their own replication. The "memetic zigzag" allows us to conceptualize the relationship between instances of i-memes and e-memes, but it is the relationship between their abstract types that is more interesting. By compressing the zigzag into a generalized life cycle such as that given for biological replicators in section 2 reveals these relationships.

The proposed life cycle is depicted in Figure 5. Unlike the biological lifecycle in which the genotype was able to reproduce itself directly, i-memes are only able to *create* their associated e-memes. It is then left to these e-memes to act as templates from which new i-memes can be *learnt*. The cultural life cycle is thus more balanced, and forms a true cycle with i-memes and e-memes forming two separate but thoroughly interdependent stages both of which form part of the meme's germline.

In biology there exist organisms that reproduce via multiple stage life cycles, but there is a continuation of their genotypes through all but one stage transition where true replication can occur. This is not the case for cultural replicators, where the i-meme and e-meme stages are truly separate with replication occurring following both. A single i-meme can potentially be responsible for the creation of multiple e-memes, which can themselves each potentially act as exemplars for the learning of multiple i-memes, something not observed in biology.

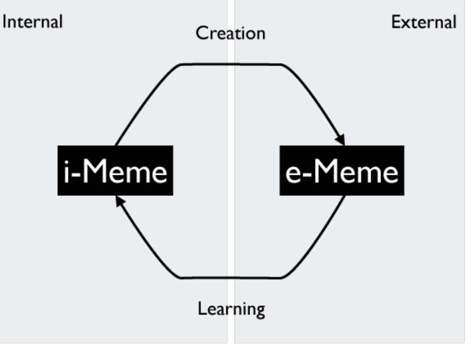

Figure 5. Cultural Replicator Life Cycle

The fact that both stages are capable of potentially producing multiple opposite phase descendants adds to the equality of the two stages. Not only are they interdependent on each other, but they also both have the opportunity to improve their own chances of replication by producing as many opposite phase copies as possible. This is hard to account for in models that focus on only brain internal or external memes, but in the life cycle model it provides little difficulty. It is possible to assume the perspective of either stage as needed when analyzing a meme's replication strategies. Essentially the brain internal and external perspectives assumed a priori in earlier meme definitions are combined in a single model, without preference given to either.

This paper does not attempt to give a formal definition of a meme as this would depend on many additional factors that have not been covered. The following characterization of a memes life cycle is however offered:

> A meme is an informational entity, which spends some of its time stored in brains as an i-meme, and some of its time encoded in the external environment as an e-meme. When in its i-meme stage it influences the behavior of its host to create its associated e-meme form. As an e-meme it influences potential hosts to learn from it and add its associated i-meme to their mental i-meme repertoire. Neither i-meme nor e-meme forms are able to directly replicate themselves and replicate only as stages in a combined meme life cycle.

This characterization makes clear not only the separation of the i-meme and e-meme stages, but also the separation of the replication steps by which they are created. Different mechanisms underlie both steps, but differential replication and introduction of variation may occur at both. The life cycle model makes the difference between the two replication steps explicit, making it easier to study the mechanisms operating at each in isolation.

6. Incremental Replication

This section demonstrates the utility of the life-cycle model by using it to analyze the process of incremental meme replication; a proposed mechanism capable of improving meme replication fidelity. As the poor copying fidelity of cultural replicators is a common critique of memetic theories (Dawkins 1999: x), processes that seemingly increase it are considered important. It is shown that incremental replication can be easily incorporated into the two-stage life cycle model.

Much of the literature on memetics seems to evoke images of memes suddenly giving birth to fully formed copies; there is a discrete act of creation. But a closer consideration of learning shows that this is seldom the case. When attempting to learn something, learning generally proceeds through a sequence of closer and closer approximations to the original idea being learnt. Misunderstandings occur, false conclusions are reached, and examples misinterpreted, but gradually over multiple exposures a close approximation of the original exemplar being learnt from is reached.

Consider learning a few common foreign phrases while on holiday in a foreign country. When a phrase is first encountered it may be possible to deduce some aspect of its meaning, and perhaps remember part of its phonetic form, but likely only with a low degree of accuracy. However, as the phrase is encountered repeatedly over the course of the holiday the i-meme copy of that phrase will gradually improve. With sufficient exposure, the i-meme copy will likely be sufficiently accurate that it can create associated e-memes with sufficient accuracy to be understood.

Copying fidelity of most i-memes based on a single exposure to an associated e-meme is incredibly low, so low that based on it alone, positive adaptations would be at constant risk of being swamped by mutations. High fidelity single exposure copying is however not necessary; so long as multiple exposures can be expected before a learner is likely to create a significant number of e-meme copies, high fidelity incremental replication is sufficient. A few mutant e-memes may be created before the i-meme is learnt perfectly, but once this happens many more high fidelity copies will be created.

The process of incremental replication is depicted in Figure 5 below. Existing i-memes create several e-meme copies in the environment. Following interaction with one of these e-memes a new i-meme is created in the brain of an individual. Initially it is only a poor copy of the original i-meme, but gradually with exposure to additional e-memes the individual is able to improve their i-meme copy. Eventually a high fidelity copy of the original i-meme is learnt and the replication process is ready to be repeated.

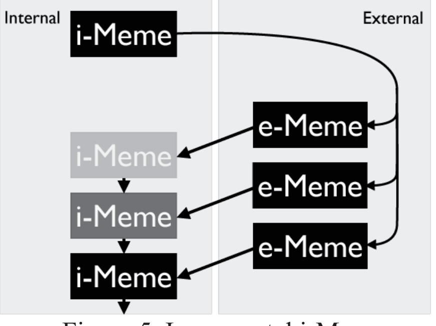

Figure 5. Incremental i-Meme Replication

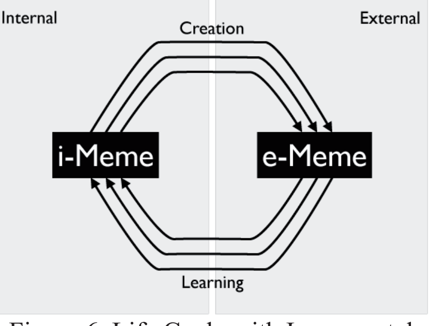

Figure 6. Life Cycle with Incremental Replication

Iterative replication may seem intuitive for memes of sufficient size that they appear not to be able to be learnt instantly, such as the phrase example above, but it also has significance for smaller memes. Consider the linguistic example of learning the phonetic form of single new lexeme after hearing it used in a television news broadcast. A single lexeme can often be learnt perfectly from only a single e-meme exposure, but there is always the possibility of the learner having misheard it or of the e-meme having been malformed. Subsequent exposures to that e-meme will however either confirm the originally learnt i-meme, or in the case of a mistake, help correct it.

It is not only the process of learning i-memes that is subject to iterative replication, e-meme creation may also benefit. Consider the collaborative creation of an e-meme by multiple individuals working together. In this case a single e-meme may be created gradually from interactions with multiple i-memes, with progressively more accurate copies being created following each interaction. A possible example of this process could be the translation of a book from one language to another by a group of scholars. A first approximation is made by one, and is then gradually improved by the others fixing errors based on their own i-meme knowledge of the original work.

Iterative copying and learning has been depicted in the life cycle diagram depicted in Figure 6 by the addition of multiple arrows between the two meme stages. E-memes are still created by i-memes, and i-memes learnt from e-memes, but this is no longer necessarily a one step process. The next section develops these links further by arguing that the importance or i-meme-e-meme interactions extend beyond when accurate i-meme replication is achieved.

7. Meme Reactivation

This section extends the analysis of incremental replication to include the related process of meme reactivation. Meme reactivation is suggested as a process whereby the fecundity of both i-memes and e-memes can be enhanced by improving the fecundity of already existing opposite phase copies. The process is easily integrated into the life cycle model, despite it being unclear how it could be incorporated into the models implicit in earlier definitions. The importance of replication even in cases where a meme has reached fixation is discussed with reference to incremental replication and meme reactivation.

Even once an i-meme copy of an e-meme has been accurately learnt, the replication of the original e-meme is not yet guaranteed. A second stage in the replication cycle still has to take place with the creation of a new e-meme copy. If existing e-memes are able to make this creation more likely, they will benefit if they do so. It is suggested that meme reactivation provides a way by which this can be achieved.

When an i-meme has not been used for a prolonged period of time its influence on the behavior of its host degrades. It may eventually be completely forgotten, but before that happens it will simply become more difficult for its host to remember. If however an i-meme is exposed to copies of its associated e-meme, or is used in their creation, this gradual degradation can be halted and even reversed. This provides a potential mechanism whereby e-memes can influence the fecundity of already existing i-meme copies and thus gives them a way to improve their own replication fecundity.

Multiple examples of this phenomenon can be seen in linguistics, including the degradation in language fluency of a speaker isolated from their original speech community, but who is quickly able to regain fluency upon returning to it. During isolation their lower fluency will act to impede production of e-memes of that language, but reintegration with the speech community will quickly reactivate the i-meme knowledge. A different lower level example can be seen in psycholinguistic *priming* (Pickering & Branigan 1999), in which recently encountered syntactic patterns or lexical items are found to be more easily interpreted by speakers and are more likely to be used in production.

A conceptual representation of meme reactivation is depicted in Figure 7. An i-meme is seen to slowly degrade through disuse over time, only to be reactivated by contact with an appropriate e-meme in its external environment. This contact induces the i-meme's host to *recall* the i-meme, and increases their likelihood of being influenced by it in the future. This potentially results in more e-meme copies being produced. Figure 8 depicts the meme life cycle with the potential for e-memes to recall i-memes being labeled on the multiple interaction edges introduced in the previous section. The analogous e-meme *reactivation* process is also labeled and will be discussed below.

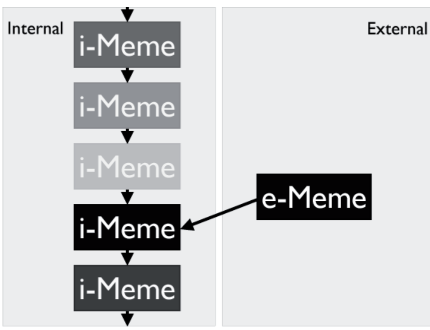

Figure 7. i-Meme Reactivation

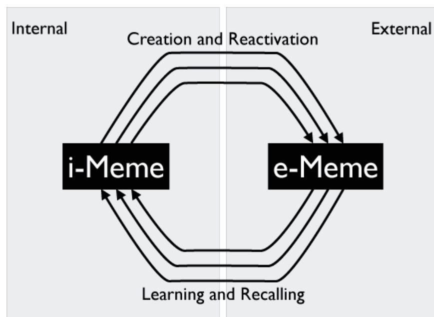

Figure 8. Life Cycle with Meme Reactivation

It is not only i-memes whose influence is subject to degradation through disuse. E-memes that persist long enough in the environment are equally susceptible. Historically this was not an issue for language e-memes; the spoken word did not have sufficient permanence such that it could fall into disuse before it naturally faded away. The development of writing, and more recently of various recording technologies, has changed this however by increasing the longevity of linguistic e-memes significantly.

Consider linguistic e-memes present in a library book. After being returned to the library it will spend some time on the recent returns shelf, and then be shelved. If not used the book will slowly start to gather dust, be moved to the library's storage stacks, and eventually be thrown away. The further along in this process the book is, the less likely its e-memes are to be encountered. If at any point someone comes across an appropriate i-meme, and decides to look up the book, not only are the e-memes given a chance to influence the borrower, but the book is also *reactivated* by being moved to a location where it has more chance of being noticed. Perhaps someone will see it on the borrower's desk, or maybe on the recently returned shelf. An i-meme having influenced its host to look up the book has increased its associated e-meme's fecundity.

The above example demonstrates an important advantage of the two-stage life cycle model, as not only has replication been split in two, but so have all other interactions between meme stages. Even though the processes of e-meme reactivation and i-meme recall have many similarities, they are not the same. The life cycle model makes this distinction clear and provides a vocabulary for discussing both sides of it. In single stage meme life cycle models it would be difficult to discuss both directions of meme reactivation and recall equally. The assumed primacy of one direction in these models makes it easier to overlook the other.

Both meme reactivation and incremental copying show that even in situations where an i-meme has reached fixation within a population (i.e. being known by all individuals), there are still evolutionary advantages to producing additional e-meme copies. Copies may not be able to spread the i-meme further, but they can help maintain the accuracy and activation of i-memes already present in the population. There is no "good enough" point past which additional e-meme production will fail to contribute to the survival of the i-meme. A similar situation also holds for e-memes that reach fixation in the environment.

8. Multiple Meme Products

The final topic we consider in relation to the life cycle model is Blackmore's distinction between Copy-the-Product and Copy-the-Instructions memes (1999: 61). This distinction is seen as being particularly important as it was the cause of Blackmore's refusal to subscribe to either a brain-internal or brain-external view of memes (1999: 64). In this section the distinction is clearly analyzed in terms of the life cycle model, and it is argued that it exemplifies the potentially important mechanism of e-meme *specialization*.

Of the two types of memes Blackmore distinguished, *Copy-the-Product* memes are perhaps the most common; in the terminology of our model, they are memes where the i-meme is learnt directly from exposure to an associated e-meme. This single e-meme provides both the motivation for, and the exemplar from which the i-meme is learnt. Examples of this type include seeing how to spell a word from its usage in a newspaper article, or learning the pronunciation of a foreign word by hearing it used in conversation.

In contrast *Copy-the-Instruction* memes are those special cases in which instead of learning an i-meme directly from an e-meme, a special set of instructions is created to help the learning process. The specific example Blackmore considered was a bowl of pumpkin soup. After tasting it and finding it to your liking, you have incentive to want to replicate it, but without having observed the creation process, you are unlikely to be able to create a particularly high fidelity copy of that particular soup. This problem is resolved by asking for a copy of the soup recipe, which is itself an e-meme! There are thus two separate e-memes involved in the replication of the soup, the pumpkin soup recipe and the pumpkin soup itself. What is the relationship between these and which form part of the meme?

An advantage of the life cycle model is that we don't have to choose between the two when choosing what to label as the meme. A slight modification to the model allows both e-memes to be included. They are both created by a single i-meme and together contribute to the maintenance of that i-meme, but are otherwise independent. The proposed extended lifecycle is depicted in figure 9 below.

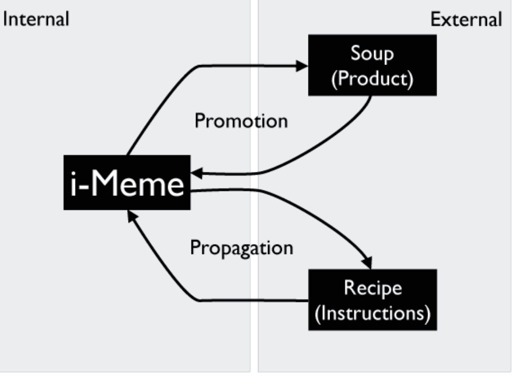

Figure 9. Copy-the-Instruction Life Cycle

Life cycles containing multiple e-memes differ from those containing a single one in that each e-meme is no longer solely responsible for all aspects of the replication of the associated i-meme. This opens up the possibility of e-meme specialization, with each e-meme specializing to promote some aspect of i-meme replication. This appears to be what is happening in the copy-the-instructions life cycle depicted above. The product e-meme is specialized to promote the meme; it provides as strong an incentive as possible for individuals to learn the associated i-meme, even if this causes it to become a poor exemplar for i-meme learning. The instructions e-meme on the other hand specializes in propagation of the i-meme; it provides almost no incentive to learn the associated i-meme, but makes learning as easy as possible when attempted. Independently these two e-memes would likely fail, but in cooperation they have a strong likelihood of success.

The distinction between product and instruction e-memes has obvious linguistic parallels in the form differences between natural and taught language acquisition. Any e-meme primarily created to aide acquisition of some aspect of the language is an instruction e-meme. This applies not just to second language acquisition tools such as the contents of foreign language textbooks or language lessons, but also to e-memes with a similar role in first language acquisition. This includes parent's corrections of children's mistakes, school textbooks and teacher's lessons on grammar and spelling rules.

Instruction e-memes exist in a wide range of different forms. The language learning examples just given are primarily composed of linguistic forms, they are expressed in language, either written or spoken. But instructions are not limited to language based forms. Gestural forms such as miming a particular sequence of actions, performing an action at a slower than normal speed, or exaggerating important features of an action are all equally capable of serving as instructions. Another possibility is the creation of simplified versions of normal product e-memes specifically to make them easier to replicate. There are also many other possibilities.

A final point to note is that in cases where specialized instruction e-memes exist, i-meme learning may still take place based directly on the product e-meme. The product e-meme may still functions as a normal copy-the-product e-meme, while being assisted in its replication by the specialized instruction e-meme. There are likely other cases of normal product e-memes being assisted by specialized forms performing some additional task. The reverse case of i-memes specializing in the creation of a single e-meme is also considered possible; for example with specialized knowledge on the part of multiple individual creators working together. Instruction e-memes are only a single example of a specialized meme form, but they serve to demonstrate the possibility of meme specialization and its use in explaining the existence of certain types of meme products.

9. Applications and Future Directions

The two-stage life cycle model of cultural replicators presented in this paper combines the advantages of earlier brain-internal and brain-external definitions of memes while avoiding much of the confusion they caused. The two previous approaches are shown not to be alternatives at all; they are in fact completely compatible, once we move away from a standard single stage model of reproduction. The two-stage model, by not committing a priori to a brain-internal or brain-external perspective, allows either to be adopted interchangeably as is necessary to explain the phenomena under consideration. This adds considerable flexibility to the model and allows a wider variety of explanations than was possible working under earlier definitions.

Further benefits of the two-stage model arise from its implicit division of the meme replication process into two steps. This allows i-meme-to-e-meme and e-meme-to-i-meme replication steps to be clearly distinguished and removes the temptation to lump the two distinct processes together. This eases the study of selection, inheritance and variation introducing processes occurring at each step and allows for analysis of tradeoffs arising from differing selection pressures operating at each step. The division of the life cycles into stages also leads naturally to the analysis of more complex patterns of replicator replication such as life cycles containing specialized meme forms that would have been difficult within the confines of a single stage life cycle model.

The model presented here provides a possible foundation for an evolutionary theory of language change, but still lacks many necessary components. Amongst other things, a framework of linguistic selection and variation is still required. This paper avoided discussing such components in an attempt to first understand what linguistic information is, before looking at how it changes. The development of a compatible framework of selection and variation is an obvious next step in the current research program. It is hoped that any resulting theory of language (and cultural) change will benefit from the theoretical groundwork laid in this paper.

In addition to development in this Darwinian direction, there are other ways in which the life cycle model could profitably be extended. The discussions on incremental copying, meme reactivation and multiple meme products in this paper focused almost exclusively on the e-meme-to-i-meme direction of interaction, but as was noted throughout the paper equivalent interactions occur in the opposite direction. These interactions need to be better studied. One particularly interesting example in this direction is the possibility of multiple functionally equivalent, though divergent, i-memes, being learnt as different interpretations of a single common e-meme and yet managing to form a stable life cycle.

Other complex life cycles that include specialized memes, such as those seen in the copy-the-instructions life cycle, are thought to be worthy of further study. Multiple opportunities for memes to add specialized components to their life cycles exist, and meme specialization may find use in explaining certain aspects of linguistic and cultural behavior that currently seem puzzling. One example of such behavior is religious rituals performed in secret. Such rituals contribute little to the associated memes propagation, but can be seen to benefit the activation of an individuals associated i-memes, offering a potential adaptive advantage. Specialized memes are far easier to study as part of a multiple stage life cycle model as the relationship between different meme forms can be clearly defined.

A final direction of future work is the investigation of meme replication strategies in relation to replication costs at replication and learning stages. Where meme production is relatively cheap (i.e. language use) it is expected that the sorts of replicators that succeed will differ systematically from those that succeed where production is more expensive. The life cycle model is useful in this investigation due to its implicit separation of production and learning costs, and the greater variety of reproduction strategies it can differentiate.

Acknowledgements

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References

Benzon, W. (1996). Culture as an evolutionary arena. *Journal of Social and Evolutionary Systems*, 19, 321–62.

Blackmore, S. (1999). *The Meme Machine*. Oxford: Oxford University Press.

Bloch, M. 2000. A well-disposed social anthropologist’s problems with memes. In R. Aunger (Ed.), *Darwinizing Culture*: *the status of memetics as a science*. Oxford; New York: Oxford University Press.

Brodie, R. (1996). *Virus of the Mind*. Seattle: Integral Press.

Chomsky, N. (1986). *Knowledge of Language.* New York: Praeger.

Cloak, F. T. (1975). Is a cultural ethology possible? *Human Ecology* 3, 161–182.

Crick, F.H.C. (1958). On Protein Synthesis. *Symposia of the Society for Experimental Biology. XII*, 139–163.

Crick, F.H.C. (1970). Central Dogma of Molecular Biology. *Nature* 227, 561–563.
Croft, W. (2000). *Explaining Language Change*: *An Evolutionary Approach.* Harlow, Essex: Longman.
Croft, W. (2008). Evolutionary linguistics. *Annual Review of Anthropology*, vol. 37, W. H. Durham, D. Brenneis and P. T. Ellison (eds.), 219–34.
Csikszentmihalyi, M. (1993). *The Evolving Self*. New York: Harper Collins.
Dawkins, R. (1976). *The Selfish Gene*. Oxford: Oxford University Press.
Dawkins, R. (1982). *The Extended Phenotype*. Oxford: Oxford University Press.
Dawkins, R. (1999). Foreword in Blackmore, S. *The Meme Machine*. Oxford: Oxford University Press.
Dediu, D. & Ladd, D. R. (2007). Linguistic tone is related to the population frequency of the adaptive haplogroups of two brain size genes, ASPM and Microcephalin. *PNAS* 104: 26, 10944–10949.
Delius, J. (1989). Of mind memes and brain bugs, a natural history of culture. In W. A. Koch, (Ed), *The Nature of culture*. Bochum, Germany: Bochum Publications.
Dennett, D. (1991). *Consciousness Explained*. New York: Little, Brown & Co
Dennet, D. (1995). *Darwin's Dangerous Idea*. New York: Simon & Schuster Paperbacks.
Durham, W.H. (1991). *Coevolution*: *Genes, Culture and Human Diversity.* Stanford, CA: Stanford University Press.
Fitch, W.T, Hauser, M.D. & Chomsky, N. (2005). The evolution of the language faculty: Clarifications and implications. *Cognition* 2005(97), 179–210.
Hull, D.L. (1988). *Science as a Process.* Chicago: University of Chicago Press.
Lai, C.S.L., Fisher, S.E., Hurst, J.A., Vargha-Khadem, F.,& Monaco, A.P. (2001). A forkhead-domain gene is mutated in a severe speech and language disorder. *Nature* 413, 519–523.
Lass, R (1996). Of emes and memes: On the trail of the wild replicator. *Vienna English Working Papers, 5.*
Johannsen, W. (1911). The genotype conception of heredity. *American Naturalist 45*, 129–159.
Pickering, M. J., & Branigan, H. P. (1999). Syntactic priming in language production. *Trends in Cognitive Sciences,* 3, 136–141.
Ritt, N. (1996). Darwinising historical linguistics: applications of a dangerous idea. *Vienna English Working Papers*, 5.
Ritt, N. (2004). *Selfish sounds and linguistic evolution*: *a Darwinian approach to language change.* Cambridge: Cambridge University Press.
Rose, N. (1998). Controversies in Meme Theory. *Journal of Memetics – Evolutionary Models of Information Transmission*, 2.
Weismann, A. (1892). *Das Keimplasma*: *eine Theorie der Vererbung*. Jena, Germany: Fischer.
Williams, G.C. (1966). *Adaptation and Natural Selection*. Princeton: Princeton University Press.